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MYCOLOGIA

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VOL. LIII SEPTEMBER–OCTOBER, 1961 NO. 5

A TAXONOMIC ANALYSIS OF SECTION ATHELE OF THE GENUS CORTICIUM. II[1]

ANTHONY E. LIBERTA

(WITH 7 FIGURES)

Bourdot and Galzin's (**1911**) establishment of section *Athele* of *Corticium* has been previously discussed in Part I (Liberta, **1960**). In 1928, these authors placed thirteen taxa in their section *Athele: Corticium gemmiferum* B. & G., *C. glaucinum* B. & G., *C. auriculariae* B. & G. (as a subspecies), *C. spurium* Bourd., *C. spurium* Bourd. forma *olivacea* Bourd., *C. lembosporum* Bourd., *C. confusum* B. & G. (as a subspecies), *C. Helianthi* B. & G., *C. Aurora* Berk. & Br., *C. juncicolum* Bourd. (as a subspecies), *C. filicinum* Bourd., *C. thymicolum* B. & G. (as a subspecies), and *C. Lloydii* B. & G.

In Part I *Corticium Aurora* (= *C. juncicolum*), *C. filicinum, C. thymicolum,* and *C. Lloydii* were found to have affinities in the genus *Xenasma* and the appropriate transfers were made. The remaining members of the section are discussed in the present paper, in the order cited above. In addition, the single species placed by Bourdot and Galzin (**1928**) in section *Athele* of the genus *Gloeocystidium* is also discussed. Concerning this species, these authors reported: "the unique species of this section corresponds to the group of the same name in *Corticium:* plants arid, growing on ferns, rushes, etc., with very compact

[1] Based on a portion of a thesis submitted to the Graduate College of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy, under the direction of Professor D. P. Rogers.

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parts; spores subcylindrical, very obliquely attenuated at the base, sometimes navicular, clinging in groups of 2–4."

Drawings were made from slide preparations stained in 0.5 N NH_4OH and Congo Red. Melzer's solution was used to determine spore amyloidity and sulfuric-benzaldehyde, as recommended by Boidin (**1951**), used to determine the presence of positively reacting gloeocystidia or to test the reaction of previously described gloeocystidia.

Colors given with the initial letter capitalized are in accordance with Ridgway's *Color Standards*. Names of herbaria are abbreviated as in the fourth edition of the *Index Herbariorum*, the brackets indicating the location of the specimens cited. The sign (!!) following a binomial indicates that the type or lectotype was examined, while the sign (!) indicates that authentic material was seen. Brackets ([ ]) around dates are used where a correct date has been substituted for that carried on a title page.

1. CORTICIUM GEMMIFERUM Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 250. 1911 (!!); Hym. Fr. p. 210. *fig. 66*. 1928. FIG. 1

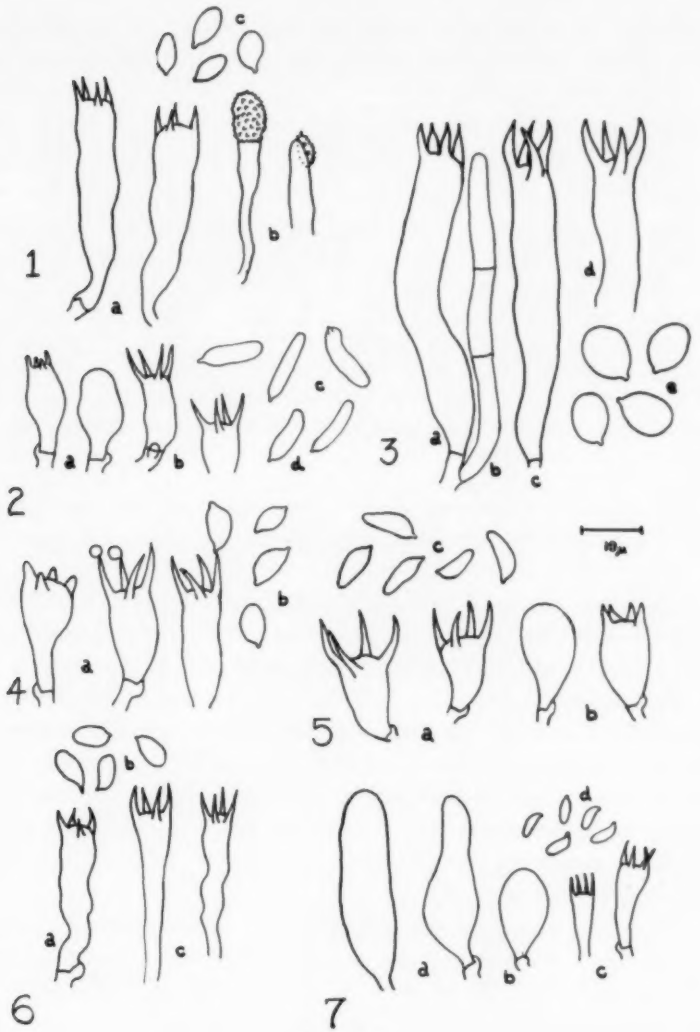
Fructification effused, thin, in section 35–75 μ thick, Light Buff to Pinkish Buff, crustaceous-subpulverulent, margins pruinose or with numerous rhizoidal strands, under a lens the surface of the hymenium dotted with minute glistening resinous droplets; subiculum 10–30 μ thick, composed of compact, distinct, prostrate hyphae which give rise to an extensive trama, nodose-septate, (1–)1.5–5 μ in diam; cystidioles abundant in the hymenium, with caps of resinous material, 15–31 × 2.5–5 μ; basidia clavate, (11–)12–37 × 4.5–7.5 μ, bearing four slender sterigmata 3–5 μ long; basidiospores hyaline, the wall smooth, nonamyloid, obovate to subfusiform or fusiform-elliptical, 4.5–7.5(–9) × 3–4.5(–5) μ.

On decayed wood of *Acer, Alnus, Cerasus, Quercus, Rubus, Ulmus,* and *Prunus spinosa*. Known from France.

Specimens examined: France: St. Priest, Allier, 9.IX.1908, *Bourd. 5816* (PC), LECTOTYPE; 30.III.1911, *Bourd. 29745* (PC); 2.IX.1911, *Bourd. 29746* (PC).

This species was excluded from *Xenasma* because of the terminal, clavate basidia which have a basal septum and the hyphae which are distinct rather than conglutinate or gelatinized.

Bourd. 5816, in addition to bearing a collecting date which is earlier than that of publication, has a note on the specimen jacket indicating the journal in which the species was originally described as well as the manuscript number assigned to it at the time of publication. Therefore, this collection has been designated lectotype.



FIGS. 1–7

FIG. 1. *Corticium gemmiferum:* a: basidia, b: incrusted cystidioles, c: spores, from type. FIG. 2. *C. glaucinum:* a, b: basidia, c: spores, from type of *C. glaucinum;* d: spores, from type of *C. auriculariae.* FIG. 3. *C. spurium:* a, c, d: basidia, b: paraphysoid hypha, e: spores, from Galz. 12268. FIG. 4. *C. pausiacum:* a: basidia, b: spores, from Galz. 16321. FIG. 5. *C. lembosporum:* a, b: basidia, c: spores, from Galz. 4292. FIG. 6. *C. Helianthi:* a: basidium, b: spores, from Bourd. 6774; c: basidia, from Galz. 5852. FIG. 7. *Gloeocystidium cretatum:* a, b: gloeocystidia, c: basidia, d: spores, from Galz. 6642.

2. CORTICIUM GLAUCINUM Bourd. & Galz., Hym. Fr. p. 207. 1928 (!!); Litsch., in Pilat & Lindtner, Bull. Soc. Sci. Skoplje Sect. Sci. Nat. **18**: 177. 1938. FIG. 2

Corticium auriculariae Bourd. & Galz. (as subsp. under *C. Helianthi*), Hym. Fr. p. 207. 1928 (!!); Litsch., Österr. Bot. Zeits. **88**: 110. 1939.

Fructification effused, thin, in section 30–40 μ thick, Ivory Yellow to Massicot Yellow, glaucous, under a lens appearing minutely porous-reticulate to subpellicular, loosely adherent; hyphae distinct or partially collapsed, nodose-septate, 2–3(–3.5) μ in diam; basidia flexuous-clavate or ellipsoid to slightly ventricose, 8–18 × 4.5–6(–7.5) μ, bearing four slender sterigmata 3–6 μ long; basidiospores hyaline, the wall smooth, nonamyloid, subcylindrical with both ends slightly tapered, occasionally depressed on one side, 7–11(–12.5) × 2.5–3.5 μ, often clinging together in groups of two or four.

On old wood of *Castanea, Fagus sylvatica,* and on *Auricularia mesenterica, Ganoderma applanatum,* and *Polyporellus varius.* Known from Austria, France, and Yugoslavia.

Specimens examined: France: Aveyron: Le Rec, 12.VI.1910, *Galz. 6029* (Bourd. 18540, TYPE of *C. glaucinum;* PC); Vialette, 23.VII.1909, *Galz. 4330* (Bourd. 6554, TYPE of *C. auriculariae;* PC).

The name *"Corticium auriculariae"* was printed in "slanted type," apparently to indicate that it was meant to be considered a subspecies. Usually a subspecies of Bourdot and Galzin (**1928**) followed directly the species to which this subcategory was meant to apply. However, these authors were not always consistent in this practice, since the species to which this subspecies was certainly meant to apply followed, rather than preceded, the subcategory.

Corticium glaucinum and subspecies *C. auriculariae* coincide with one another in color and texture as well as microscopic features, making it impossible to readily separate one from the other. Therefore, subspecies *C. auriculariae* is herein reduced to synonymy.

Both of these taxa were apparently described from single collections, and the specimens examined are most certainly type. The collector's data on the respective specimen jackets are the same as those given at the time of original description.

This species was excluded from *Xenasma* for essentially the same reasons as cited under *C. gemmiferum.*

3. CORTICIUM SPURIUM Bourd., Rev. Sci. Bourb. **1922**: 15. 1922 (p. 4 of repr., 1922) (!!); Bourd. & Galz., Hym. Fr. p. 206. *fig. 61.* 1928. FIG. 3

Fructification effused, in section up to 110 μ thick, Cream-Buff to Naples Yellow, hypochnoid to loosely membranous, adherent; hyphae thin-walled, light yellow, densely packed in the subhymenium, slightly irregular or collapsed, simple-septate, 3–7 μ in diam; simple paraphysoid hyphae present in the hymenium, 3.5–5 μ in diam; basidia produced in heads, arising at various levels in the subhymenium, the older ones becoming progressively immersed, often filled with large oil droplets, clavate to long subcylindrical, (30–)33–71(–75) × 6–9 μ, bearing four stout, divergent sterigmata (5–)7.5–10.5 × 1.5–2 μ; basidiospores hyaline, the wall smooth, nonamyloid, obovate to subglobose, 8–11 × 5–8 μ.

On humus, moss, and decayed wood of *Quercus*. Known from France.

Specimens examined: France: Aveyron: Costo-Roumive, 29.XI.1912, *Galz. 12268* (Bourd. 9229; PC); Congues, 16.VII.1912, *Galz. 11608* (Bourd. 8974; PC), LECTOTYPE; Balzaguet, 26.XII.1913, *Galz. 14938* (Bourd. 12401; PC).

This species is easily recognized by its long, relatively narrow basidia, and large obovate to subglobose spores. It was not included in *Xenasma* (Liberta, **1960**) because its microscopic characteristics do not coincide with those of that genus.

Galz. 11608, in addition to being the earliest collection of this species, has on its jacket measurements which coincide with those given in the original description. Therefore, it is herein designated lectotype.

4. **Corticium pausiacum** Liberta, nom. nov. FIG. 4

Corticium spurium Bourd. forma *olivacea* Bourd., Rev. Sci. Bourb. **1922**: 16. 1922 (p. 5 of repr., 1922) (!!); Bourd. & Galz., Hym. Fr. p. 206. 1928 (not *C. olivaceum* ([Fr.] ex Pers.) Fr.).

Fructification effused, in section up to 170 μ thick, Saccardo's Umber or between Isabella Color and Light Brownish Olive, hypochnoid, occasionally finely cracked, the margins minutely porous-reticulate, under a lens the cracked areas of the hymenium revealing a lighter colored subhymenium, adhering loosely to the substratum; subiculum scanty, the subhymenium extensive, composed of distinct, compact, subhyaline to light olivaceous hyphae, nodose-septate, 2–6 μ in diam; basidia obpyriform to clavate or subcylindrical, contents at first olivaceous brown, when mature fading to subhyaline, 15–23(–25) × (6–)7–9 μ, bearing four rather stout sterigmata 5–8(–9) × 1–1.5 μ; basidiospores subhya-

line, the wall smooth, nonamyloid, obovate or navicular to subnavicular and appearing biapiculate, 6–7.5 × 4–5 μ.

On stems of *Calluna vulgaris* and wood of *Castanea*. Known from France.

Specimens examined: France: Aveyron: Balzaguet, 5.X.1909, *Galz. 4706* (Bourd. 14772; PC). LECTOTYPE; Bouisson, 1.XII.1910, *Galz. 5154* (Bourd. 14773; PC); Beno, 9.VI.1913, *Galz. 13438* (Bourd. 9720; PC); Loubotis, 1.X.1914, *Galz. 16321* (Bourd. 14854; PC); Canteloup, 22.VIII.1915, *Galz. 18473* (Bourd. 29741; PC).

This species is easily distinguished by its olivaceous basidia and spore morphology. It does not resemble *Corticium spurium* in any microscopic feature, because not only are the hyphae of *C. pausiacum* nodose-septate rather than simple-septate, but also the olivaceous basidia are quite different morphologically from the hyaline basidia of *C. spurium*. On the basis of these gross differences, the forma is herein given specific rank.

5. CORTICIUM LEMBOSPORUM Bourd., Rev. Sci. Bourb. **23**: 10. 1910 (p. 8 of repr., 1910) (!!); Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 245. 1911; Hym. Fr. p. 208. 1928. FIG. 5

Corticium confusum Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 250. 1911 (!!); Hym. Fr. p. 208. 1928 (as subsp. under *C. lembosporum*); G. H. Cunningham, Trans. Roy. Soc. New Zealand **82**: 308. *fig. 24*. 1954.

Fructification effused or maculiform, thin, in section 20–80 μ thick, white to Ivory Yellow, farinose-pellicular to submembranous, occasionally cracked, the margins pubescent or pruinose to minutely porous-reticulate, easily separable; subiculum of distinct hyphae, giving rise to a subhymenium of compact, often collapsed hyphae (1–)1.5–5 μ in diam, clamp connections abundant; basidia oblong or obovate to short clavate, 9.5–22 × 5–11 μ, bearing four stout, curved, divergent sterigmata (4.5–)5–8(–9) × 1.5–2 μ; basidiospores hyaline, the wall smooth, nonamyloid, narrow navicular to blunted subulate, 7–12 × 2.5–4.5(–5) μ, often clinging together in groups of two or four.

On stems of *Pteridium aquilinum*, *Athyrium filix-foeminae*, wood and twigs of *Acer campestre*, *Tsuga heterophylla*, and *Abies*. Known from France, California, and Oregon.

Specimens examined:

France: Aveyron: St. Sernin, 23.VII.1909, *Galz. 4292* (Bourd. 6517, TYPE of *C. lembosporum;* PC); Vergnas, 9.X.1910, *Galz. 7116* (Bourd. 7625, TYPE of *C. confusum;* PC).

California: Spruce Cove, Trinidad, 20.I.1947, *H. E. Parks* (TRTC; D. P. Rogers).

Oregon: Comstock, 6.XI.1937, *A. M. & D. P. Rogers 3907;* between Sweet Home and Cascadia, 20.XI.1937, *A. M. & D. P. R. 381* (FH), *401* (TRTC), *593;* Detroit, 5.XI.1938, *H. M. Gilkey, A. M. & D. P. R. 493* (TRTC).

Bourdot and Galzin placed *Corticium confusum* in section *Athele* in 1911, but *C. lembosporum* was not included until 1928. These authors recognized the close affinity of these two taxa when, in their major work Hyménomycètes de France, *C. confusum* was printed in "slanted type" directly following *C. lembosporum* to indicate that it was reduced to subspecific rank. In addition, *C. confusum* was described in 1928 as an intermediate between *C. lembosporum* and *C. filicinum* Bourd.

In this analysis, *C. lembosporum* and *C. confusum* were found to coincide with one another in all respects, the differences being insufficient to warrant retention of the latter in any rank. However, the basidia and distinct hyphae of *C. lembosporum,* as it is now understood, were found to be quite different from those of *Xenasma* (*Corticium*) *filicinum.*

Apparently *C. lembosporum* and *C. confusum* were each described from a single collection. The collector's data on the respective specimen jackets are the same as those given at the time of original description. Therefore, *Galz. 4292* is herein considered the type of *C. lembosporum* and *Galz. 7116* the type of *C. confusum.*

6. CORTICIUM HELIANTHI Bourd. & Galz., Hym. Fr. p. 207. 1928 (!). FIG. 6

Fructification effused, thin, in section 40–60 μ thick, Cream-Buff to Cream, crustaceous, under a lens appearing minutely porous to ceraceous-membranous, the surface minutely cracked, loosely adherent; subiculum of a few prostrate hyphae giving rise to an extensive subhymenium of branched, often collapsed hyphae, clamp connections abundant to very rare, 2–3(–3.5) μ in diam, acicular crystals occasionally occurring in the subhymenium; basidia clavate, somewhat flexuous, 15–28 × 4–5(–6) μ, bearing four slender sterigmata (3–)3.5–5(–6) μ long; basidiospores hyaline, the wall smooth, nonamyloid, oblong and attenuated toward the base to ellipsoid and laterally depressed, (4–)4.5–7.5 × 3–4 μ.

On stems of *Helianthus tuberosus* and *Eupatorium cannabinum.* Known from France.

Specimens examined: France: St. Priest à Croûtet, Allier, 12.IX. 1909, *Bourd. 6774* (PC); Aveyron, 6.V.1910. *Galz. 5852* (Bourd. 14297; PC).

This species is readily distinguished by its long and relatively narrow, flexuous basidia, as well as its oblong or ellipsoid spores. The specimens examined are certainly paratypes, since the data on the jackets of each specimen are the same as those given at the time the species was first described. *Galz. 5852* shows abundant clamp connections while in *Bourd. 6774* the clamp connections are rare. Nevertheless, these two collections closely resemble one another in all other respects.

C. Helianthi was excluded from *Xenasma* on the basis of its terminal basidia with a basal septum, and the distinct or collapsed nature of the hyphae.

7. GLOEOCYSTIDIUM CRETATUM Bourd. & Galz., Bull. Soc. Myc. Fr. **28**: 371. [1913] (!); Hym. Fr. p. 265. 1928. FIG. 7

Fructification effused, in section 20–135 μ thick, Cartridge Buff to Cream Color, farinose-membranous, loosely adherent; hyphae distinct, nodose-septate, 1.5–2.5 μ in diam; gloeocystidia irregular, obovate or claviform to cylindrical or fusiform, the contents resinous, not staining in sulfuric-benzaldehyde, 15–45 × (3.5–)4.5–9 μ; basidia clavate, 8–18 × 3.5–4(–5) μ, bearing four slender sterigmata 2–4 μ long; basidiospores hyaline, the wall smooth, nonamyloid, oblong-ellipsoid and laterally depressed to subcylindrical and attenuated at the base, 4–5 × 1.5–2 μ.

On putrescent petioles of *Polystichum filix-max* and *P. spinulosum*. Known from France.

Specimens examined: France: Château Charles, Allier, 27.IX.1910, *Bourd. 31684* (PC); Aveyron, VIII.1910, *Galz. 6642* (Bourd. 7531; PC).

Bourdot and Galzin's (**1928**) section *Athele* of the genus *Gloeocystidium* contained this single species. It was excluded from *Xenasma* because of its rather extensive subhymenium of distinct hyphae and terminal basidia which have a basal septum.

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Liberta, A. E. 1960 [1962]. A taxonomic analysis of section *Athele* of the genus *Corticium*. I. Genus *Xenasma*. Mycologia **52**: 884–914.

NEW OR NOTEWORTHY PENICILLIA FROM WISCONSIN SOILS [1]

MARTHA CHRISTENSEN AND M. P. BACKUS

(WITH 7 FIGURES)

In this paper two new species of *Penicillium* are described. Descriptions are also given for three entities, identified respectively as *Penicillium canadense* Smith, *P. dalcae* Zaleski, and *P. radulatum* Smith, which were isolated from Wisconsin soils but seem not to have been previously recorded from the United States.

All of the molds in question here were first encountered in a survey study of the microfungi of upland conifer-hardwood forest soils in northern Wisconsin (Christensen, **1960**), where they were isolated by the dilution plate method from the A_1 horizon. Later three of them were found again in soils from northern lowland communities of the State, especially conifer bogs.

Since several of these Penicillia appear to be abundant only in association with certain higher plant dominants, ecological specificities have been noted. The higher plant vegetational areas of Wisconsin from which most of the isolates came have been fully characterized by Curtis (**1959**). The terms "frequency" and "density," where employed in discussing the occurrence of any fungal species in a given area, are according to the definitions of Tresner, Backus, and Curtis (**1954**).

Czapek's agar and malt extract agar (hereinafter referred to simply as "malt agar"), employed for culturing the various molds, were prepared according to the formulae published by Raper and Thom (**1949**). Unless otherwise indicated, all morphological descriptions have been based on examinations of cultures on malt agar incubated at room temperature for 10 to 16 days. To give greater precision in describing cultural characteristics, the color standards of Ridgway (**1912**) have been used at vari-

[1] This study was supported in part by funds from the Wisconsin Alumni Research Foundation, allocated by the Research Committee of the University of Wisconsin Graduate School; it was also supported in part by grant No. G8912 from the National Science Foundation. The taxonomic counsel of Professor Kenneth B. Raper at various points in this study and the guidance of the late Professor J. T. Curtis relative to the ecological aspects of the investigation are gratefully acknowledged.

ous points. References to specific Ridgway plates will be found in the text.

PENICILLIUM CANADENSE Smith

A *Penicillium* which the writers have concluded may be referred to *P. canadense* Smith (Smith, **1956**) was isolated 31 times from Wisconsin soils. It was present at low frequencies in seven upland forests dominated by white pine, red pine-white pine, and red pine-hemlock; and it occurred at a comparatively high frequency (in 5 of 8 sites sampled) in one of five cedar-fir bogs included in a Wisconsin lowland survey. It has not been isolated from spruce-larch or open bog peats, however, nor from any sites supporting hardwood forest (Tresner, Backus, and Curtis, **1954**; Christensen, **1960**), prairie (Orpurt and Curtis, **1957**), or sedge meadow communities. Thus, in Wisconsin, this entity appears to be a soil form particularly adapted to moist conifer forest communities lacking sphagnum in the ground cover, but with a well-developed mor humus layer. Smith's type culture of *P. canadense* was isolated from soil of a Douglas Fir nursery in western Canada.

Selected Wisconsin isolates were compared in detail with a subculture of Smith's type, obtained from the Commonwealth Mycological Institute; and a close similarity in both cultural and morphological features was observed. The only significant difference noted was in the conidia, those of the Wisconsin form being predominantly citriform and definitely roughened whereas the type culture produces globose to citriform spores with essentially smooth walls. This difference might warrant recognition of a special variety, but it is thought best to delay the proposal of such a taxon until larger numbers of isolates are obtained and studied. Smith (**1956**) considers *P. canadense* to be closely allied to *P. albicans* Bain., in the group Polyverticillata.

The description of the Wisconsin entity which follows has been drawn principally from a detailed study of cultures WSF 992 and WSF 3830, which are being maintained in our culture collection.

Colony on malt agar 4 to 9 cm in diameter in 14 days at room temperature. Black substrate mycelium; margin fimbriate; surface plane, deep velvety, sulphine yellow shading to citrine and dark citrine (Rdg. IV) or dull citrine (Rdg. XVI); reverse black; no exudate; odor not distinctive.

Colony on Czapek's agar 4 to 5.6 cm in diameter in 14 days at room temperature. Margin fimbriate; surface velvety, at first cinnamon-buff to Saccardo's umber (Rdg. XXIX) becoming straw-colored near dark olive buff to citrine drab (Rdg. XL) with formation of conidia; reverse

clove brown (Rdg. XL) to nearly black; no exudate; odor not distinctive.

Conidiophores arising directly from the substrate, commonly 500 to 900 μ but up to 1390 μ long by 4.5 to 7.1 μ in diameter, stiff, thick-walled, conspicuously septate, sometimes sinuous apically; wall deep yellowish-brown, smooth or nearly so. Penicilli polyverticillate, very compact, usually asymmetrical, with up to four levels of branching below the sterigmata; in penicilli showing three stages of branching, the elements are commonly arranged as follows: verticils of metulae and sterigmata are attached to the apex of the conidiophore, and additional groups of metulae and sterigmata are attached to the apices of 2 to 6 lateral branches which arise at the first node below the terminal metulae; other lateral branches with 2 to 3 levels of additional branching may be present at lower nodes on the conidiophore stalk; primary, secondary, and tertiary branches wedge-shaped, successively smaller in diameter, 9 to 19 μ by 3.5 to 6 μ; metulae wedge-shaped, 8 to 12μ by 3.5 to 5 μ; sterigmata 7 to 10.5 μ by 3 to 4 μ, abruptly tapered and with long conidium-bearing tips. Conidia in tangled chains; mostly citriform, yellowish, with roughened walls, average measurement 4 by 3.5 μ but ranging from 4 by 3.1 μ to 5 by 4 μ; separated by narrow connectives about 0.5 μ in length. Occasionally in place of the normal sterigmata, elongate, hyaline, irregularly constricted filaments are present; in cultures on Czapek's agar, these may predominate; in malt agar cultures, they are rare and most penicilli contain only normal sterigmata.

The outstanding characteristics of this form are colony color (black mycelium, straw-colored conidia), dark bristle-like conidiophores, and compact polyverticillate penicilli.

PENICILLIUM DALEAE Zaleski

A single isolate, obtained from a red pine-white pine forest soil in Portage County, Wisconsin, has been identified as *P. daleae*. *P. daleae* appears to be a rare fungus, having been reported only once (Al-Doory, Tolba, and Al-Ani, **1959**) since its original isolation by Zaleski (**1927**) from soil under pines near Poznan, Poland.

The following description is based on culture WSF 682, which is being maintained in our laboratory. In general, the Wisconsin isolate conforms with Thom's (**1930**) description of Zaleski's species, although it differs in producing longer conidiophores and shorter sterigmata.

Colony on malt agar 3.8 cm in diameter in 10 days at room temperature. Surface floccose, plane, dark grayish olive to deep grayish olive (Rdg. XLVI) with a narrow white margin; reverse honey yellow occasionally pink-tinged, shading through amber brown to chestnut (Rdg. XXX; III; II) centrally; no exudate; odor not distinctive.

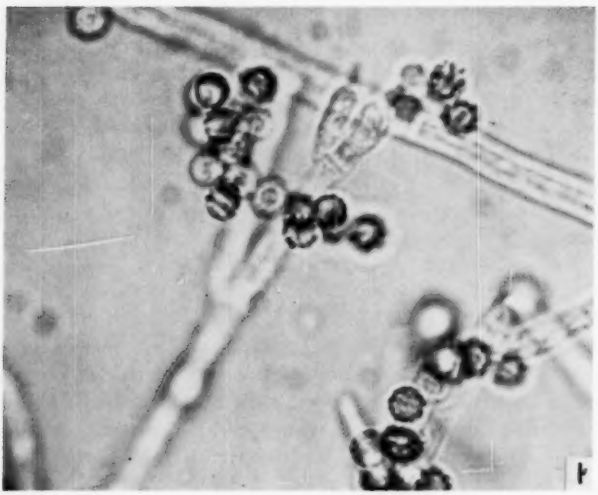


FIG. 1. *Penicillium daleae*, WSF 682. Spore-bearing structures and echinulate banded conidia. × 1700.

Colony on Czapek's agar 1.8 to 2.2 cm in diameter in 10 days at room temperature; felt-like with a tough basal mat, often deeply wrinkled marginally. Surface white, but appearing near rhodonite pink (Rdg. XXVIII) because of intense reverse pigmentation, fresh cultures slowly becoming grayish olive (Rdg. XLVI) with formation of conidia; reverse bordeaux to mars violet (Rdg. XII; XXVIII), often with greenish-yellow overtones; colorless exudate drops formed, particularly in the crevices; odor not distinctive.

Conidiophores arising directly from the substrate and from loosely trailing hyphae, commonly 400 to 550 μ long by 2 to 3 μ in diameter, smooth, uncolored. Penicilli asymmetric-divaricate; metulae mostly 10 μ to 35 μ by 2 to 3 μ, smooth, with slightly vesicular apices; sterigmata commonly in verticils of 6 to 8 though sometimes single on the metula, slightly divergent, often with long-tapered tips (FIG. 1) reminiscent of *Penicillium janthinellum* Biourge, 6.2 to 8 μ by 2.5 to 3 μ. Conidia in tangled chains; oval to subglobose, thick-walled, conspicuously echinulate with spines up to 0.5 μ long concentrated in 3 to 5 transverse bands (FIG. 1), 3.5 to 4 μ by 3 to 3.2 μ, mostly 3.7 μ by 3 μ; separated by narrow connectives about 1 μ in length.

The outstanding characteristics of this form are the intense purple-red reverse pigmentation on Czapek's agar, asymmetric-divaricate penicilli, and production of large, coarsely echinulate, banded conidia in tangled chains.

PENICILLIUM RADULATUM Smith

A mold which appears to be relatively abundant in the soil in certain Wisconsin habitats but which, insofar as we have been able to discover, has not previously been reported from the United States, has been identified as *Penicillium radulatum* (Smith, **1957**). This entity was isolated 82 times from A_1 horizon soils in northern Wisconsin under nearly pure stands of conifers (especially hemlock and cedar-fir) and from a single red oak soil; it was not reported from southern hardwood or prairie soils of Wisconsin (Tresner et al., **1954**; Orpurt and Curtis, **1957**) and has not been found in spruce-larch or open bogs, sedge meadows, or floodplain forests of this state. In Christensen's (**1960**) study of the microfungi of northern upland forest soils, it appeared to be an indicator species for acid podzolic soils with low base exchange capacity. Smith also found *P. radulatum* in acid podzolic soils. His type culture came from a *Calluna* heath soil in Britain, and he listed the species as common in that habitat.

The Wisconsin isolates were found to be very similar, both culturally and morphologically, to a subculture of the type for *P. radulatum* received from the Commonwealth Mycological Institute. The type culture differs only in that it has a slightly faster growth rate on Czapek's agar—colonies reaching a diameter of up to 4.2 cm at 14 days. The description which follows was drawn especially from a detailed study of cultures WSF 809 and WSF 3454, which are being maintained in our collection.

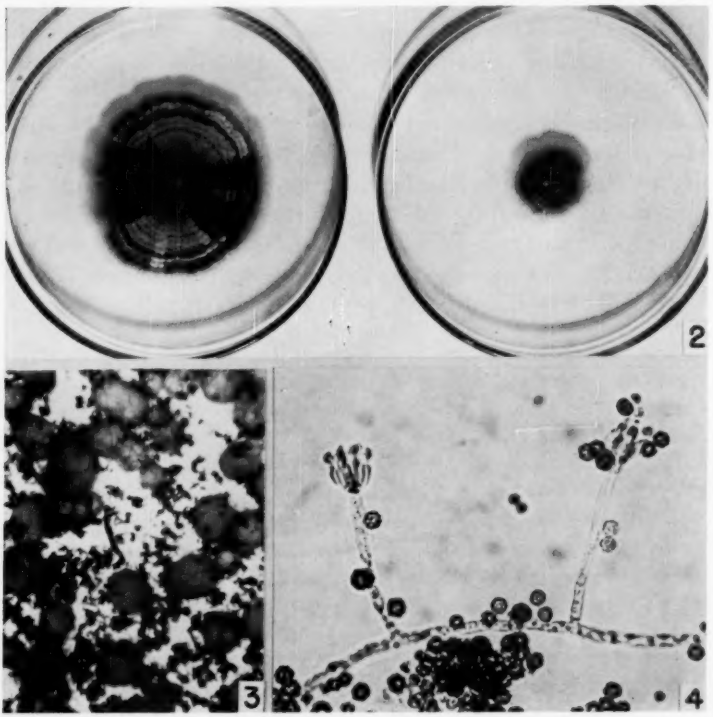
Colony on malt agar 3.4 to 5.3 cm in diameter in 14 days at room temperature. Surface velvety, plane, white at the margin but quickly shading to deep slate olive (Rdg. XLVII); reverse deep yellow near yellow ocher or old gold (Rdg. XV; XVI) from pigment which diffuses into the agar, occasionally with a rust tinge centrally and in radiate streaks; no exudate; faint, pleasant odor.

Colony on Czapek's agar 2.4 to 3.2 cm in diameter in 14 days at room temperature; tough, felt-like, depressing the agar. Surface plane or with radial folding, white tardily becoming slate olive (Rdg. XLVII); reverse strong yellow-orange near deep chrome to xanthine orange (Rdg. III) darkening to russet (Rdg. XV); abundant amber-colored exudate produced throughout central part of colony; no distinctive odor. With continued maintenance of an isolate on agar, the reverse color is diminished in intensity and the exudate drops may become nearly colorless.

Conidiophores commonly arising directly from the substrate in malt cultures, 30 to 280 μ by 3 to 5 μ in diameter; walls granular-tuberculate. Penicilli asymmetric-divaricate; branches and metulae scattered on the conidiophore and variable in length, mostly 12 to 24 μ by 3 to 4 μ, walls

granular or granular-tuberculate; metulae terminally vesicular to about 5 μ broad; sterigmata 5 to about 10 per metula, 7 to 9 μ by 2.2 to 3.2 μ, with walls definitely granular in malt cultures. Conidial chains loosely columnar, becoming tangled and crusting in age; marginal columns up to 100 μ long by 8 to 10 μ broad; conidia olive-colored by transmitted light, globose, thick-walled, spiny-tuberculate, occasionally appearing banded, 3 to 4 μ in diameter.

The outstanding characteristics of this form are the deep slate olive colony color, abundant production of amber-colored exudate on Czapek's agar, roughened conidiophores, and asymmetric-divaricate penicilli in which all elements are conspicuously roughened.



FIGS. 2–4. *Penicillium pinetorum*, WSF 15-c. FIG. 2. Sixteen-day-old colonies on malt and Czapek's agar. FIG. 3. Surface view of colony on malt agar showing sclerotia and columns of conidia. × 50. FIG. 4. Short conidiophores and globose spiny conidia characteristic of the species. × 600.

Penicillium pinetorum Christensen & Backus, sp. nov. FIGS. 2–4

Coloniae in agaro maltoso post dies decem calore mediocri 4–5 cm diam. attingentes, velutinae, atroflavo-virides postea olivaceae, cum sclerotiis in zonis concentricis et cuneatis frequenter dispositis; reversum incoloratum. Conidiophorae ex hyphis aetheriis repentibus vulgo nascentes, 10–88 × 2.5–4.3 μ, in apicibus ad 5 μ dilatae, incoloratae vel subcoloratae, paululum asperulae. Penicilli monoverticillati; phialides 5–9 in verticillis compactis 7.5–13 × 2–3.5 μ. Conidia in columnis 15–20 μ diam., globosa, primum glabra deinde asperrima, plerumque 5–5.5 μ diam. Sclerotia dispersa vel acervatim disposita, dura, globosa vel subglobosa, ad 330 μ diam., primum albo-flava deinde fulva. Habitat copiose in solo pinetorum in Wisconsin boreali, U.S.A.

Colony on malt agar 4 to 5.1 cm in diameter in 10 days at room temperature. Surface velvety, andover green to slate-olive becoming dark ivy green in age (Rdg. XLVII); yellow to tan colored sclerotia abundant and characteristic in most isolates, sparse in others and often failing to develop after continued maintenance of an isolate on agar; sclerotia typically in sectors and in concentric bands which contrast with the deep green zones of sporulation; reverse uncolored; no exudate; no distinctive odor.

Colony on Czapek's agar 1.3 to 2 cm in diameter in 10 days at room temperature. Colony thin, powdery, near deep olive (Rdg. XL) in color; sclerotia in sectors, often more abundant on this medium than on malt agar; reverse uncolored; no exudate; no distinctive odor.

Conidiophores usually arising as short perpendicular branches from trailing hyphae, 10 to 88 μ commonly 20 to 40 μ by 2.5 to 4.3 μ; stalk uncolored or faintly pigmented, delicately roughened, ending in an apical swelling 5 μ or less in diameter. Penicilli mostly strictly monoverticillate; sterigmata nearly parallel in compact clusters, 5 to 9 per apex, commonly 8 μ by 3 μ but ranging from 7.5 to 13 μ by 2 to 3.5 μ, wall sometimes appearing delicately roughened. Conidia adhering in columns up to 290 μ long in old cultures by 15 to 20 μ broad; uniformly globose, smooth when young, but later with spines up to 1 μ long, thick-walled, not banded, mostly 5 to 5.5 μ in diameter at maturity. Sclerotia scattered and in small clusters, commonly involved in a loose network of uncolored hyphae; gritty; globose to subglobose, mostly 140 to 180 μ but up to 330 μ in diameter; Marguerite yellow darkening to honey yellow (Rdg. XXX) in age.

The outstanding characteristics of this species are short, roughened conidiophores arising as perpendicular branches along trailing hyphae; monoverticillate penicilli; very spiny, globose conidia; and hard, yellow to tan sclerotia occurring in sectors and in concentric zones which contrast with the dark green conidial zones.

Sclerotium development in this species appears to be temperature

related, since incubation of *P. pinetorum* cultures at temperatures of less than 24° C has been found to enhance sclerotium production. Tube cultures stored in a refrigerator at 7° C invariably show a profuse development of sclerotia at the colony margin; and likewise, plate cultures on malt agar initially grown at room temperature and then moved to 7° C or 18° C incubators, or incubated alternately (for 24-hour periods) at 24° C and 7° C produce a far greater number of sclerotia than do cultures incubated continuously at 24° C or higher.

Penicillium pinetorum is assignable to the *Penicillium thomii* Series on the basis that it is a monoverticillate form regularly producing gritty sclerotia. But no taxon hitherto recognized in this Series has spiny globose conidia, delicately echinulate conidiophore walls, and yellow to tan sclerotia which are not covered by a weft of colored hyphae. Professor Kenneth B. Raper has kindly examined cultures of the entity from pine woods and agrees with us that it has not previously been described. In our opinion, *P. thomii* Maire is probably its closest known relative. However, the latter species is easily distinguished by its longer conidiophores, its smooth-walled, often elliptical conidia, and its sclerotia, which are usually pinkish orange.

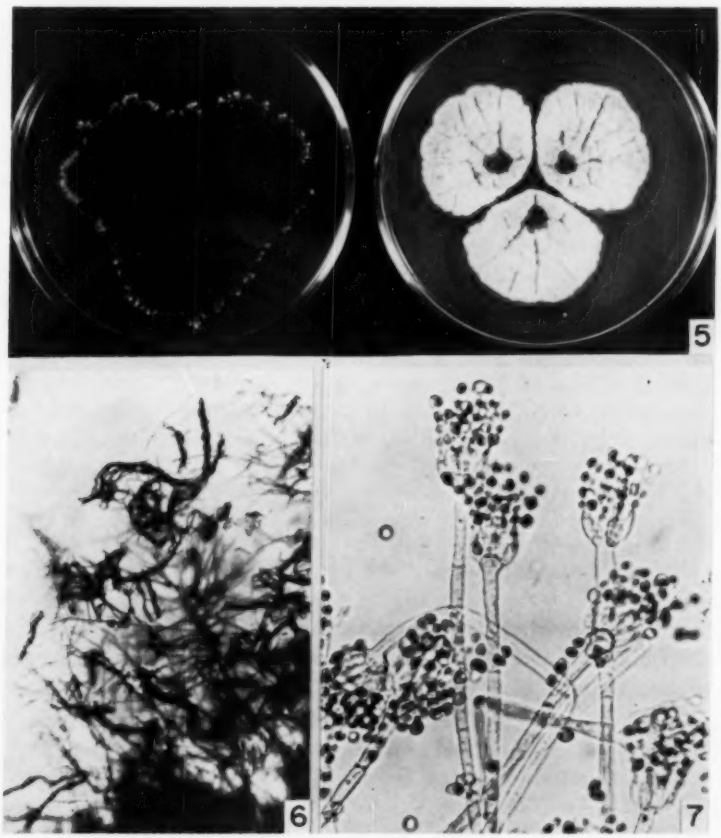
The specific epithet, *"pinetorum"* (of pinewoods), has been selected because of the common occurrence of this species in pine forest soils of Wisconsin. The species description is based principally upon the type culture, WSF 15-c, which was isolated from A_1 horizon soil collected in a white pine-birch forest in Vilas County, Wisconsin.

Penicillium pinetorum was obtained from soil in 15 of the 36 Wisconsin conifer-hardwood forests sampled and was represented here by a total of 139 isolates; at least in this State it appears to be a characteristic soil mold in forests dominated by red pine or white pine or both (Christensen, 1960). Two additional isolates, in all essential respects identical with WSF 15-c, were obtained from a lodgepole pine soil collected in Yellowstone Park, Wyoming.

Cultures of *P. pinetorum* WSF 15-c have been deposited in the American Type Culture Collection, Washington, D. C., and with the Centraalbureau voor Schimmelcultures, Baarn, Netherlands. TYPE material in the form of dried plate cultures of WSF 15-c have been placed in the Cryptogamic Herbarium of the University of Wisconsin, in the Cryptogamic Herbarium of The New York Botanical Garden, New York, N. Y., and in the Herbarium at the Commonwealth Mycological Institute, Kew, Surrey, England.

Penicillium odoratum Christensen & Backus, sp. nov. FIGS. 5–7

Colonies in agaro maltoso post hebdomades duas calore mediocri 2.2–5 cm diam. attingentes, crassae, velutinae, venetae vel atrogriseo-virides, margine fimbriata, reverso incolorato vel subflavo, odore fortiter frangranti oderem malorum simulanti; penicillis monoverticillatis, conidiophoris ex hyphis magnis repentibus plerumque nascentibus 100–560 × 3–4 μ, septatis, crasse asperulatis, incoloratis, conidiophori apice ad 7–10 μ in diam. dilato et 10–18 sterigmata parallela 7–12 × 3–4 μ gerenti; conidiis in columnis 16–30 μ latis et usque ad 500 μ longis, primum ellipticis deinde ovatis vel subglobosis 3–4.1 × 2.2–4 μ fere 3.5–4 × 2.8–3.2 μ, membrano crasso as-



FIGS. 5–7. *Penicillium odoratum*. FIG. 5. WSF 2000, sixteen-day-old colonies on malt and Czapek's agars. FIG. 6. WSF 1203, surface view of malt agar colony margin, showing stolon-like extensions and conidial chains in long columns. × 60. FIG. 7. WSF 1203, conidiophore apices and ovate conidia. × 600.

perulate et subcostato. Habitat copiose in solo palustri *Chamaedaphne-Ledum-Kalmia* at *Picea-Larix* sustineanti in Wisconsin boreali, U.S.A.

Colony on malt agar 2.2 to 5 cm in diameter in 14 days at room temperature. Margin commonly with well-developed stolon-like hyphae which give rise to peninsular ridges of conidiophores in advance of the colony mat; surface Artemisia green to lily green and deep slate green (Rdg. XLVII), plane, deep velvety; conidia in long columns; reverse uncolored to yellowish near sulphine yellow (Rdg. IV); no exudate; odor very strong, resembling the aroma of apples.

Colony on Czapek's agar 3 to 7 cm in diameter in 14 days at room temperature. Marginal area thin, with coarse radiate hyphae growing both at the agar surface and submerged; these send lateral extensions downward, and give rise to short, erect conidiophores. Surface sporulating tardily; color, texture, and column development as on malt agar but conidiophores more widely spaced; reverse uncolored to light yellow-brown or gray brown near tilleul-buff or avellaneous (Rdg. XL), somewhat darker at colony center; exudate lacking or in small colorless drops; odor penetrating, fragrant.

Conidiophores arising primarily from the stolon-like hyphae, 100 to 560 μ long by 3 to 4 μ in diameter, septate, coarsely roughened, uncolored, sometimes slightly sinuous, with well-developed lens-shaped vesicles commonly 7 to 9 μ in broadest dimension but up to 10 by 6.5 μ. Penicilli monoverticillate; sterigmata about 10 to 18 per vesicle, crowded, parallel, typically 9 to 12 μ (6.5 μ in one isolate) by 3 to 4 μ. Chains of conidia in columns up to 500 μ long by 16 to 30 μ, tangling in age and falling away *en masse* when the culture vessel is tapped; conidia elliptical at first, becoming ovate to subglobose, 3 to 4.1 μ by 2.2 to 4 μ commonly 3.5 to 4 μ by 2.8 to 3.2 μ, thick-walled, with roughening concentrated in transverse ridges so that the spores appear faintly banded.

The outstanding features of this taxon are the deep blue-green color and penetrating fruity odor of the colony; coarse, radiate, stolon-like hyphae; roughened conidiophores up to 560 μ long with broad apical vesicles; and monoverticillate penicilli, ending in columns of ovate, roughened, faintly banded conidia.

Penicillium odoratum resembles certain members of the *P. lividum* and *P. frequentans* Series, but differs from all described species in the two series in colony color or texture, vesicle size, conidiophore length, shape and sculpturing of the conidia, or a combination of these features. Its closest relative probably is *P. trzebinskianum* Abe (Abe, **1956**); the latter species, however, develops a darker colored reverse on both Czapek's and corn steep agar, has a vanilla-like odor instead of the apple-like odor that is so characteristic of *P. odoratum*, has shorter

conidiophores (60 to 280 μ vs. up to 560 μ), has somewhat smaller conidiophore apices, and is not described as having either conspicuous stolon-like hyphae or the resultant irregular colony margin. Professor Kenneth B. Raper has kindly examined cultures of this entity and agrees that it cannot readily be assigned to any described species. The specific epithet, "*odoratum*," selected for the new taxon refers to the pronounced aromatic character of all isolates obtained.

Culture WSF 2000, isolated from the peaty soil of a spruce-larch community in Taylor County, Wisconsin, is designated as the TYPE for this species; and the description provided is based in large part on this culture. However, over a period of years, a relatively large number of isolates (about 225) of *P. odoratum* have been screened in our laboratory, and some variations have been noted among them. For instance, there were some differences in growth rate, in the amount of stolon formation, in sterigma length, etc.; but the most striking difference concerned pigment formation in the medium. Colonies of some isolates exhibited a strong yellow to grayish brown reverse, often with some diffusion of pigment out into the surrounding agar medium, whereas other isolates, including the type culture WSF 2000, showed no reverse coloration. Cultures WSF 1203, 2002, 3200, 3201, and 3894, which, together with WSF 2000, represented the full range of variation observed, were all studied in detail and were all used to some extent in formulating the species diagnosis. A number of isolates were grown on various media in addition to Czapek's and malt agar to discover what effect this might have on aroma. All isolates tried proved to develop the characteristic odor on all media used, and it was usually particularly strong on substrates rich in sugar, including potato-dextrose agar.

Penicillium odoratum has proved to be a common and abundant member of the soil microfungal flora in lowland spruce-larch and open bog communities of Wisconsin. It was the only species present in all layers (surface to 18 inches) sampled in a vertical section through the sphagnum mat of a spruce-larch bog, and accounted for 73.6% and 50.9% of the isolates from the whitish and light brown layers of sphagnum at depths of approximately 1 and 3 inches, respectively. In a spruce-larch community survey, *P. odoratum* was present in all of the 5 bogs sampled, had an average frequency of 52.5% (sites of occurrence, 8 sampling sites per community) and accounted for 5.5% of the 1060 spruce-larch isolates. In northern Wisconsin open bog communities, dominated by leatherleaf (*Chamaedaphne calyculata*), Labrador tea (*Ledum groenlandicum*), bog laurel (*Kalmia polifolia*), the bog Rosemary (*Andromeda glaucophylla*) over a thick growth of sphagnum moss, *P. odoratum* was

present in 4 of 5 communities sampled at an average frequency of 43.8% and average density of 4.7%. A total of 207 isolates assignable to this species were obtained from the 10 Wisconsin spruce-larch and open bog communities. Ten additional isolates occurred in the microfungal populations of 2 cedar-fir soils, and 6 representatives of the species were obtained from the A_1 soils of 5 widely scattered upland conifer-hardwood forests in northern Wisconsin.

Cultures of *Penicillium odoratum* WSF 2000 have been deposited in the American Type Culture Collection and with the Centraalbureau voor Schimmelcultures. Dried plate cultures of *P. odoratum* WSF 2000 have been placed in the Cryptogamic Herbaria of the University of Wisconsin and The New York Botanical Garden, also in the Herbarium at the Commonwealth Mycological Institute.

SUMMARY

Two new species of *Penicillium* are described: *P. pinetorum,* assigned to the *P. thomii* Series and found to be relatively common in soils of Wisconsin forests dominated by red pine, white pine, or both; and *P. odoratum,* an aromatic monoverticillate form probably related to *P. trzebinskianum* Abe, which was found to be abundant in bog soils in communities of *Chamaedaphne-Ledum-Kalmia* and *Picea-Larix* in northern Wisconsin. Descriptions are also given for three mold entities, identified respectively as *Penicillium canadense* Smith, *P. daleae* Zaleski, and *P. radulatum* Smith, which were isolated from soils in coniferous areas of Wisconsin, in some cases in considerable abundance, but which seem not to have been previously recorded from the United States.

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A NEW SPECIES OF CHOANEPHORA FROM INDIA

B. S. Mehrotra and M. D. Mehrotra

(with 28 figures)

The conidiophores of *Choanephora* have generally been described to be simple. They bear at their apex only a single swollen vesicle, or there may be secondary vesicles on stalks from the primary vesicle. The stalks may be short and simple or may be long and dichotomously or irregularly branched, giving rise to secondary or even tertiary stalks. In all cases of branching each of the ultimate branches bears at its apex a conidium-bearing vesicle. In many cases where branching of the stalks occurs the primary vesicle either loses its shape or becomes insignificant. At times the apex of the conidiophore has also been seen to branch dichotomously into two halves, each bearing stalked secondary vesicles. In 1915 Saito and Naganishi (**1915**) described a species, *Cunninghamella manshurica* but later Tai (**1934**) made the new combination, *Choanephora manshurica*. One of the main distinguishing features of this species was the dichotomous branching of the conidiophore. While no materials or slides of this species are now available (personal communication, Tai, 1960) the figures and descriptions show that the dichotomous branching of the conidiophores, referred to by Tai (**1934**), was confined to the apex and probably could be considered to be branching of the stalks rather than of the conidiophores. Such branching of the stalks at the apex of the conidiophores has been seen by the authors in *Choanephora infundibulifera* (Curr.) Sacc. also. Naganishi and Kawakami (**1955**, p. 175, pl. 2, fig. 16B) also observed an abnormal conidiophore showing an apical branching in *Choanephora infundibulifera*. Zycha (**1935**) and Hesseltine (**1953**) considered *Choanephora manshurica* (Saito & Naganishi) Tai as a synonym of *Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.

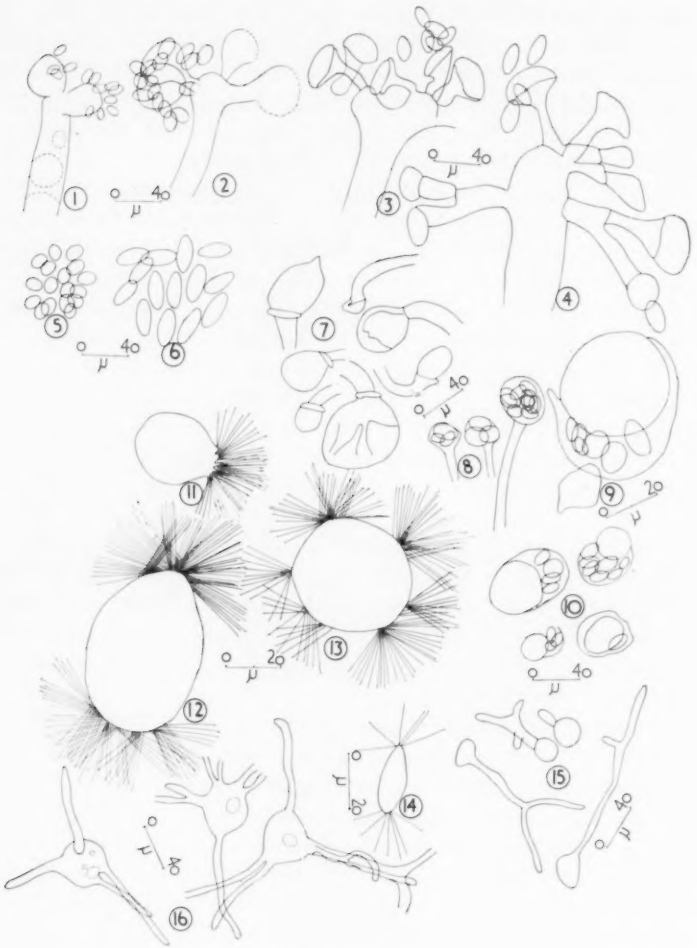
No species of *Choanephora* has so far been observed to show a branching of the conidiophore much below the apex which could be taken as a true branching of the conidiophore and could never be considered as a branching of the stalks subtending the secondary vesicles. Further, the sporangiospores in the sporangium or sporangiolum of *Choanephora*

have always been found to be alike and of the same size range. The variation in size of the sporangiospores in a sporangium or sporangiolum has always been seen to be within a reasonable range and it had never been reported that one or two of the sporangiospores were two to three times or even larger than the average-sized spores of the same sporangium or sporangiolum under any cultural conditions.

During the course of our studies of the Choanephoraceae we found a *Choanephora* growing on a dead insect. This isolate showed not only branchings at the apex of the conidiophore but also branching of the conidiophores much below the apical region in a few cases. Each such branch acted as a simple conidiophore usually giving rise, at its apex, to a number of stalks subtending conidium-bearing secondary vesicles. Besides this, especially under poor nutritional conditions (under which sporangiola are usually produced in *Choanephora*), the species was found to produce heterosporous sporangiola having one or two sporangiospores markedly larger than the rest in the same sporangiolum. This feature also has been seen rarely in sporangia. The heterosporous condition of sporangiola has never been reported in *Choanephora* and probably in any of the fungi under any cultural conditions. Its presence under certain cultural conditions (poor nutritional conditions) and absence under others does not contradict the fact that heterospory exists in this organism. Size variations in spores have been induced by Shattuck (**1910**) in a well known heterosporous pteridophyte, *Marsilea,* by altering the physiological conditions.

The larger spores from a sporangiolum are beset with innumerable appendages at one to several points on their surfaces. The smaller spores are, as usual, provided with few appendages at the two ends. The mode of germination of these larger spores is also different. They germinate by putting forth germ tubes from several points of the surface while the small-sized spores germinate only by putting forth one or at the most two germ tubes. Further, the small-sized spores have never been found to attain the size of the larger spores even at the time of germination.

The mating reactions with strains of other species of *Choanephora* show that this isolate is capable of mating with the minus strain of *Choanephora cucurbitarum* (NRRL 2745) and forms perfect zygospores. This fact can be taken to mean that our isolate is related to *Choanephora cucurbitarum.* In no case should it be considered the same species. Blakeslee's earlier finding that only imperfect hybridization is possible between two allied species needs modification in view of the recent report by Hesseltine (**1960**) in which he had found perfect zygospore formation when different strains of two related genera, viz.,



FIGS. 1–16.

FIGS. 1–16. *Choanephora heterospora.* 1. A conidiophore with a bifurcated primary vesicle. The conidia are borne on the vesicle. 2. A conidiophore with a number of stalked secondary vesicles on the primary vesicle. 3. A conidiophore with a bifurcated primary vesicle, each half bearing stalked secondary vesicles. 4. A conidiophore with an elongated primary vesicle from the surface of which arise simple or dichotomously branched stalks. The ultimate stalks bear the secondary vesicles at their apex. 5. A number of conidia from conidial head bearing small sized conidia only. 6. A number of conidia from conidial head bearing larger sized conidia only. 7. A number of columellae showing the range in size and shape.

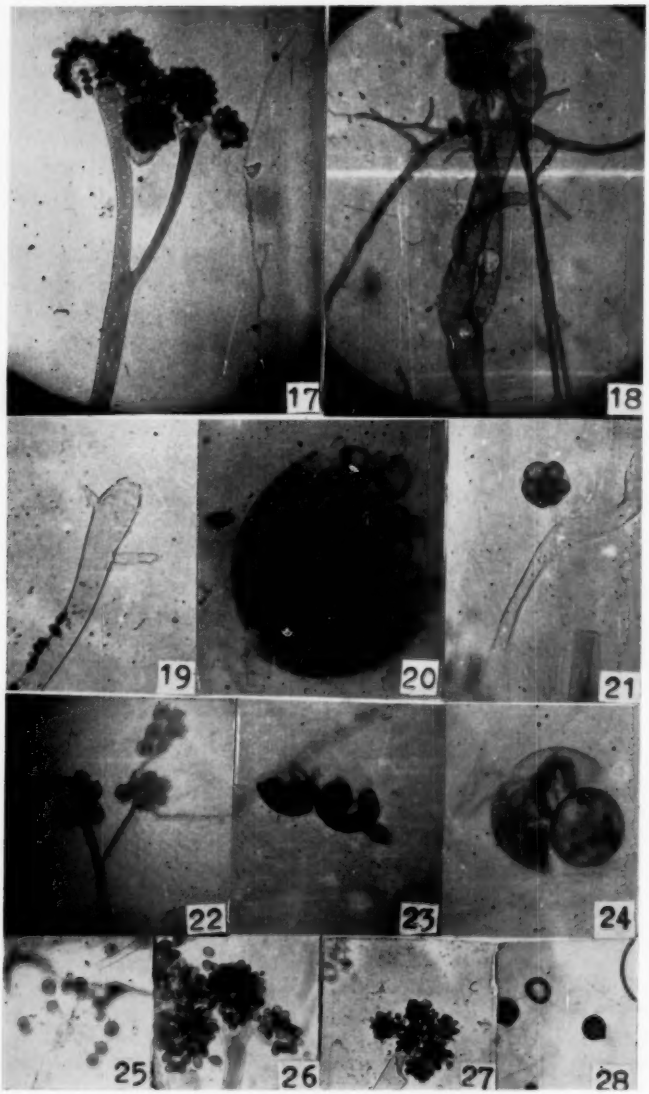
Gilbertella persicaria (Eddy) Hesseltine [NRRL 1546, (—)] and *Blakeslea trispora Thaxt.* [NRRL 2456, (+)] were mated. Hesseltine (personal communication, 1961) has recently found a new species of *Absidia* which, though distinct from *Absidia butleri* Lendn. in morphological characters of its spores, shows a perfect sexual reaction with a strain of *Absidia butleri.* The nature of the zygospores produced between two interspecific or intergeneric crosses has to be determined. It is quite possible that such zygospores may not be fertile. For this, germination studies of such zygospores would be quite useful. Nevertheless the fact remains that the substantial differences in asexual characteristics should not be overlooked even though the new isolate gives perfect sexual reaction with an allied species of the same genus.

Taking all the above facts into consideration, it appears that this isolate is one hitherto unknown. It is described as a new species based on heterospory.

Choanephora heterospora Mehrotra & Mehrotra, sp. nov.

Sporangia sphaerica vel globosa, primo incolora, tum brunneo-nigra, 43.5–101.5 μ saepius 50.5–98.7 μ, parietibus persistentibus scabris in duas dimidias partes scindentibus, brunneolis colore; columellae globosae vel pyriformes, annulo 23.0 $\times$ 45.2 μ ornatae; sporangiosporae ovoideae vel ellipsoideae, 9.9–27 $\times$ 6.6–13.2 μ, ut plurimum 16.5–22.5 $\times$ 9.9–13.2 μ, non striatae, pallide coloratae, ornatae appendicibus ad utrumque apicem; sporangiola insidentia sporangiophoris minoribus, globularia, 21.7–43.5 μ diam, vulgo 3–10 spora, rarius sporangiola monospora notantur; sporangiosporae sub conditionibus nutritionis pauperculae distincte magnitudine differunt, una vel duplici sporangiospora in singulis sporangiolis quam caeterae maiore; maiores quidem 21.0–48.5 $\times$ 19.8–48.5 μ, germinantes per plures germinationis tubos originem ducentes ex punctis diversis et appendicibus innumerabilibus ornatae ad unum pluraque puncta in superficie; minores vero 9.9–27 $\times$ 6.6–13.2 μ, germinantes vulgo ad unum vel ut plurimum ad duo puncta per simplicem duplicemve germinationis tubum; conidiophori erecti, non septati, hyalini, simplices vel furcati, posunt vero desinere in vesiculam primariam, ex qua aliae vesiculae secundariae

8. Three sporangiola showing no marked difference in the size of the sporangiospores. 9. A sporangiolum with one sporangiospore much larger than the rest of the sporangiospores. 10. Four sporangiola showing marked heterospory, one sporangiospore much larger than the rest in each case. 11. A larger sporangiospore with numerous appendages arising from one end only. 12. Another larger sporangiospore with numerous appendages at the two ends. 13. A larger sporangiospore with numerous appendages at several points on its surface. 14. A sporangiospore from a sporangium showing appendages at both the ends. 15. Four smaller sporangiospores from a sporangiolum germinating to produce a single germ tube from a single point only. 16. Three larger sporangiospores from three different sporangiola germinating to produce a number of germ tubes at several points from each.



FIGS. 17–28.

FIGS. 17–28. *Choanephora heterospora*. 17. A conidiophore with a single branch. The secondary vesicles are borne on short stalks arising from the primary vesicle of the conidiophore and also from its branch, × 150. 18. A conidiophore with

emergunt, quae directe conidia supportant; vesicula primaria abesse potest et conidiophorus potest dividi ad apicem et causare emergentiam secundariarum vesicularum ferentium conidia; posunt etiam desinere in apicem paulo latiorem, producentes ad summum apicem et paulo infra summum apicem vesiculas ferentes conidia stipitibus elongatis insidentes, stipites vero posunt nonnumquam dichotome dividi ad eorum apicem, ultimis ramis supportantibus vesiculas conidia ferentes, stipitibus 49.5–85.8 μ longis; conidiophori nonnumquam semel bisve furcantur multo infra apicem, singulis ramulis evadentibus conidiophoris simplicibus, qui ad apicem supportant plures stipites, hi vero subtendunt vesiculas secundarias conidia ferentes; conidia magnitudinis duplicis, minora quidem 9.9–17.2 × 6.6–8.9 μ, largiora vero 19.8–31.2 × 9.9–16.5 μ, vulgo utraque simul notantur in eadem vesicula, nonnumquam vero minora tantum vel maiora tantum notantur conidia in uno conidiophoro; chlamydosporae ovales, 9–16 × 17–24 μ, abundantes in cultura vetusta, ut plurimum catenulatae; zygosporae brunneae vel brunneo-nigrae, 33–89 μ, vulgo 52.8–62.7 μ.

Colony colorless when young, becoming yellowish on aging; mycelium cottony, growing rapidly; hyphae nonseptate, 2.2–9.9 μ in breadth, generally 6.6 μ, branching irregularly; sporangiophores arising from the surface hyphae, unbranched, often bent or circinate below the sporangium, hyaline; sporangia spherical to globose, at first colorless later brownish black, 43.5–101.5 μ, more often 50.5–98.7 μ, wall persistent, rough, generally breaking into two halves, brownish in color; columellae globose to pyriform, with a collar 23.0 × 45.2 μ; sporangiospores ovoid to ellipsoid, 9.9–27 × 6.6–13.2 μ mostly 16.5–22.5 × 9.9–13.2 μ, not striate, light colored, provided with appendages at both the ends; sporangiola borne on smaller sporangiophores, globular, 21.7–43.5 μ in diam, generally 3–10-spored, rarely monosporous sporangiola also seen; sporangiospores, especially under poor nutritional conditions, differing markedly in size, with one or two sporangiospores in a sporangiolum much larger than the rest; larger 21.0–48.5 × 19.8–48.5 μ, germinating by a number of stout germ tubes originating from several points and provided with innumerable appendages at one to several points on the surface; smaller 9.9–27 × 6.6–13.2 μ, germinating mostly at one point or at the most two points by one or two germ tubes; conidiophores erect, nonseptate, hyaline,

two branches, one being fertile, and the other abortive, × 150. 19. A conidiophore with two abortive branches, × 100. 20. A sporangium with one sporangiospore much larger than the rest, formed on Hay extract agar, × 200. 21. A sporangiolum with no marked difference in the size of the sporangiospores, formed on PDA, × 200. 22. A branched conidiophore with stalked secondary vesicles arising from an obliterated primary vesicle present at the end of each branch, × 50. 23. Two halves of a heterosporous sporangiolum, × 200. 24. Another heterosporous sporangiolum with one sporangiospore much larger than the rest, × 250. 25. A conidiophore with a number of stalked secondary vesicles arising from an elongated primary vesicle, × 50. 26. A conidiophore with a bifurcated primary vesicle each bearing stalked secondary vesicles, × 50. 27. A conidiophore with smaller conidia borne on the secondary vesicles, × 50. 28. Zygospores as seen in mixed culture when the fungus was first isolated, × 50.

simple or branched, may end into a primary vesicle from which secondary vesicles arise which directly bear the conidia, primary vesicle may be absent and the conidiophore may bifurcate at its apex giving rise to secondary conidium-bearing vesicles, may only end into a slightly wider apex giving rise at the tip and slightly below the tip to conidium-bearing vesicles borne on elongated stalks, the stalks may at times branch dichotomously at their apex, the ultimate branches bear the conidium-bearing vesicles, stalks 49.5–85.8 μ in length; at times conidiophores branch once or twice much below the apex, each branch acting as a simple conidiophore usually giving rise at its apex to a number of stalks subtending conidium-bearing secondary vesicles; conidia of two size ranges, smaller, 9.9–17.2 × 6.6–8.9 μ and larger 19.8–31.2 × 9.9–16.5 μ usually occurring together on the same vesicle, occasionally only large or small conidia on a conidiophore; chlamydospores oval, 9–16 × 17–24 μ, abundant in old cultures, usually present in chains; zygospores brown to brownish black, 33–89 μ, mostly 52.8–62.7 μ.

Isolated from a dead insect, Sept. 1959 at Botany Department, University of Allahabad. TYPE: Culture and slides deposited in Herbarium, Botany Department, University of Allahabad; No. M-25. Culture and slide will also be deposited at NURD, Peoria, Illinois, U.S.A.

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A NEW SPECIES OF DIDYMOSPHAERIA FROM THE RHIZOSPHERE

T. K. Ramachandra-Reddy

(with 1 figure)

Fuckel (**1869**) established the genus *Didymosphaeria* with six species, *D. peltigera* Fckl., *D. genista* Fckl., *D. galiorum* (Desm.) Fckl., *D. epidermidis* Fckl., *D. rubi* Fckl. and *D. xylostei* Fckl. Since then, several parasitic and saprophytic species of the genus have been described (von Höhnel, **1905**; Saccardo, **1928**; Petrak, **1936**; von Arx, **1954**; Wehmeyer, **1952**; Ramakrishnan, **1955**). Recently Scheinpflug (**1958**) rearranged *Didymosphaeria* into four groups and eighteen species. However, none of these authors have so far recorded *Didymosphaeria* from soil or rhizosphere of plants. The following is a description of a new species isolated from the rhizosphere soil of *Oryza sativa* Linn.

Didymosphaeria sadasivanii Ramachandra-Reddy, sp. nov.

Coloniae lente crescentes, albae vel fumosae, evadentes nigrae aetate provecta. Perithecia alte brunnea vel nigra, intermixta in superficie agari post dies septem, maturitatem attingentia post binas ternasve hebdomadas, complanata, sphaerica, 203–259 × 185–225 μ, nigro-punctata, sparsa, parietibus constantibus et cellulis brunneis vel nigra parenchymaticis. Asci lati, clavati, tenuibus parietibus praediti, bitunicati, cylindrici, brevipedicellati, poro apicali nullo, 41–64 × 9–15 μ. Sporae biseriatae, constantes e duabus cellulis quarum superior rotunda et lata, inferior vero plus fastigata, hyalina, primo granularis deinde brunneolo-lutea, 15.0–18.7 × 9.3–11.2 μ. Paraphyses septatae.

Typus separatus ex humo efformante rhizosphaeram *Oryza sativa* Linn.

Colonies slow growing, white to smoke-brown turning black on ageing. Deep brown to black perithecia interspersed on agar surface in 7 days, which mature in 2 to 3 weeks. Perithecia flattened, spherical, 203–259 × 185–225 μ, black, sparse, wall composed of black to brown parenchymatous cells. Asci broad, clavate, thin-walled, bitunicate, cylindric, short-stalked, with no apical pore, 41–64 × 9–15 μ. Ascospores biseriate, two-celled with upper cell round and broad, while the lower is more tapered, hyaline, granular at first, later turn brownish yellow, 15.0–18.7 × 9.3–11.2 μ. Paraphyses septate.

Habitat: Isolated from the rhizosphere soil of rice (*Oryza sativa* Linn.), Madras, India.

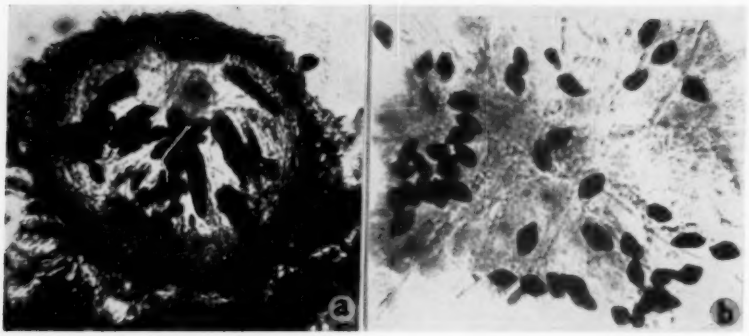

FIG. 1. *Didymosphaeria sadasivanii*. a. Transverse section of perithecium showing the asci and paraphyses (× 100). b. Two-celled ascospores (× 440).

SPECIMENS: Dried cultures are deposited at the MUBL herbarium (No. 2096 TYPE), at the Indian Type Culture Collection, Indian Agricultural Research Institute, New Delhi and at the Commonwealth Mycological Institute, Kew, England.

CULTURAL CHARACTERS: *Potato-dextrose agar:* Colonies dark grey to brown, dull brown to black on ageing, pseudothecial primordia formed in 4–7 days. Ascogenous hyphae coiled. Perithecia maturing in three weeks. Spore size and asci normal. *Czapek's agar:* Colonies white to cream coloured, mycelium hyaline, branched, septate, perithecia formed in two weeks, maturing in a month. Ascospores septate, coloured. *Soil extract agar:* Colonies dull white, mycelial growth sparse, adpressed to agar surface, mycelium hyaline, septate, perithecia appearing in two weeks maturing earlier in 18 days. *Spore germination:* Spores germinate in 8–12 hours in distilled water.

DISCUSSION

Didymosphaeria spp. are parasitic (Scheinpflug, **1958**) or saprophytic (Wehmeyer, **1952**) and are adapted for an aquatic habitat (Meyers, **1957**; Wilson and Knoyle, **1961**). The occurrence in soil indicates the cosmopolitan distribution of the genus.

The soil isolate of *Didymosphaeria* agrees with Fuckel's (**1869**), "Corticale, perithecia ut pleosporae, ascospora, didymae," which on spore size alone would fall within a group near *D. astragalina* Petr., as suggested by Müller (private communication, 1960). However, the extremely thin-walled asci indicate that *Didymosphaeria* may not be the appro-

priate genus. As there is no other genus where it can suitably be placed, and since it agrees in the broad spectrum of morphological formation of the sexual forms with *Didymosphaeria*, it is described as a new species and named *D. sadasivanii* in honour of Prof. T. S. Sadasivan, Director, University Botany Laboratory, Madras—5, for his encouragement and help extended in new lines of soil mycological studies.

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SYNOPSIS OF THE POLYPORACEAE OF THE WESTERN UNITED STATES AND CANADA

JOSIAH L. LOWE AND ROBERT L. GILBERTSON

This paper presents preliminary taxonomic information which has been developed as part of a general research program directed toward a treatment of the Polyporaceae of North America. A synopsis of the polypores of the southeastern United States (Lowe and Gilbertson, 1961) has previously been published.

The area covered here includes the western states of Alaska, Washington, Oregon, Idaho, Montana, Wyoming, California, Nevada, Utah, Colorado, Arizona, and New Mexico; the Canadian provinces of British Columbia, Alberta, and Saskatchewan; and Yukon Territory and the western portion of the Northwest Territories. Much of this area has not been explored mycologically and the wood-rotting fungus flora of most of the area is inadequately known. Increased collecting by regional workers is very desirable, and it is hoped that this paper may stimulate such activity.

The richness of a wood-rotting fungus flora seems to depend upon the variety of available substrata and the climatic factors, primarily temperature and amount and distribution of precipitation. Because the western forests are composed largely of gymnosperms, the variety of substrata is much more limited than in eastern North America where, in addition to conifers, a large number of woody angiosperms are found. Also, average annual precipitation in much of western North America is less than 20 inches. In higher elevations in the interior mountains it may be as much as 40 inches, but much of this is snow. Even in the coastal forests, where annual precipitation may total over 100 inches, the summer months preceding the critical fall fruiting period for fleshy fungi are frequently so dry that logging operations are suspended because of the extreme fire danger.

The wood-rotting fungi, in contrast to the fleshy terrestrial forms, require a relatively long period of favorable moisture and temperature conditions before their basidiocarps appear in large numbers. From our experience, we judge that in most regions of the West, a favorable season for fruiting of wood-rotting fungi may occur in one year out of five.

Because of all these factors, the number of species of polypores known from the West is considerably less than that recorded from the eastern United States and Canada. In this paper 236 species are recognized as valid elements of the flora, as compared with 293 species recognized in the southeastern United States (Lowe and Gilbertson, **1961**). In this paper *Polyporus annularis* and *Elfvingia brownii* are recombined in the genus *Ganoderma* for the first time. *Poria alpina* is reported from North America for the first time.

For a discussion of some of the major characteristics of this western polypore flora see Gilbertson and Lowe (**1962**). Although the polypore flora of the western United States and Canada includes a large number of species found in eastern North America, it seems to be more similar to that of northern Europe. It is also apparently quite similar to the polypore flora of northern Japan.

The pathological and distributional data presented here are based primarily upon the authors' field experience in western North America. During the past 10 years we have made approximately 5000 collections of wood-rotting fungi in the area covered in this paper. These collections include about 200 of the 236 species reported here. In addition to our own collections, we have examined western polypores in herbaria of a number of institutions. These include the National Fungus Collections at Beltsville, Maryland; the Forest Disease Laboratory, United States Forest Service at Laurel, Maryland; The University of Michigan; Pennsylvania State University; Washington State University; The University of Arizona; and the Plant Research Institute, Department of Agriculture, Ottawa, Ontario. Distributional data have been supplemented by inclusion of records from Overholts (**1953**), Baxter (**1932–1955**), Cash (**1953**), and Kimmey and Stevenson (**1957**).

The first regional treatments of western polypores are those of Murrill (**1912**, **1915**) who collected along the Pacific Coast in 1911, and recognized 64 species in that area. Shope (**1931**), in his treatment of Colorado polypores, included 64 species. Cooke (**1942**) published a key and descriptions for 35 species of resupinate pore fungi in Oregon. Gilbertson (**1954**) recognized 192 species of Polyporaceae in the northern Rocky Mountains and Pacific Northwest, and also (**1956**) described 64 species of *Poria* from the Northwest, and (**1961**) treated 15 species of *Trametes* in the area covered by this paper.

Among the western collectors, J. R. Weir must be given special mention. Weir, while employed by the Office of Forest Pathology of the Bureau of Plant Industry, U. S. Department of Agriculture, collected throughout the northern Rocky Mountains, and Pacific Northwest from

1911 to 1921, with headquarters at Missoula, Montana and later at Spokane, Washington. His specimens are now housed in the National Fungus Collections; these represent a monumental contribution to our knowledge of western fungi. Weir corresponded actively with the European mycologists J. Bresadola and L. Romell, and sent them representative specimens for identification. These specimens, and Weir's study of types and authentic specimens in European herbaria, enabled him to identify accurately a large number of western polypore collections. Specimens in the Bresadola material at Beltsville include many of Weir's specimens annotated by Bresadola; these provide us with a better understanding of species concepts held by that great student of the Hymenomycetes.

Other early collectors in the West were W. H. Long and C. G. Hedgcock in the Southwest; A. S. Rhoads, E. E. Hubert, C. J. Humphrey and C. H. Kauffman in the Northwest; S. M. Zeller in Oregon; and H. E. Parks in California. Among the more active recent collectors have been D. V. Baxter, L. Bonar, W. B. Cooke, R. W. Davidson, C. G. Shaw, A. H. Smith, A. W. Slipp, C. R. Stillinger, D. E. Stuntz, and W. G. Ziller. Some of these have published lists of western fungi including polypores. For a listing of these papers see Gilbertson (**1956**, **1961**). L. O. Overholts, who examined many specimens of western polypores during his researches on the group, made only one collecting trip in the West (Overholts, **1919**). Collections of western polypores were sent to him by many people, with C. R. Stillinger and A. W. Slipp making important contributions to his herbarium.

The taxonomy of the Polyporaceae at the generic level has been a controversial subject since the time of Fries, and a large number of genera have been proposed. Recent reviews of these genera have been published by Cooke (**1959**) and Donk (**1960**). For recent critical reviews of the systems of classification see Bondartzeva (**1961**) and Teixeira (**1962**). None of the systems of classification that have been proposed have met with universal acceptance, and there is no general agreement on which characters should be the basis for generic distinction. For the most part, the systems of classification proposed are based on a limited temperate flora, and the problem will probably not be resolved until our large tropical flora of polypores is better known. In this paper we are concerned primarily with species concepts and the elucidation of our western North American flora. Therefore, for convenience, we employ the old Friesian genera as the basis for the organization of the species treated here.

KEY TO THE GENERA

1a. Spores brown, appearing echinulate, truncate at one end...VI. GANODERMA
1b. Spores colored or hyaline, smooth, or if echinulate, not truncate at one end
  2a. Basidiocarps always resupinate.....II. PORIA
  2b. Basidiocarps stipitate, sessile, or effused-reflexed, sometimes resupinate at first
    3a. Basidiocarps perennial, with tubes in more or less distinct layers.....III. FOMES
    3b. Basidiocarps annual, with one layer of tubes, occasionally reviving a second year
      4a. Hymenophore typically labyrinthine.....V. DAEDALEA
      4b. Hymenophore typically radially lamellate.....VII. LENZITES
      4c. Hymenophore poroid, the pores circular to angular
        5a. Pores distinctly diamond-shaped, radially elongated; basidiocarps laterally stipitate, light colored....VIII. FAVOLUS
        5b. Pores circular to angular, rarely radially elongated
          6a. Basidiocarps stipitate, sessile, or effused-reflexed, corky to fleshy; pores large to small; spores globose to cylindrical, colored or hyaline; cystidia present or absent.....I. POLYPORUS
          6b. Basidiocarps sessile or effused-reflexed, corky to tough-fibrous; pores mostly large, 1–4 per mm.; spores hyaline, mostly cylindrical; cystidia absent.....IV. TRAMETES

I. POLYPORUS Mich. ex Fries

1a. Context brown, permanently darkening in KOH solution (for 1b, see No. 18)
  2a. Basidiocarps stipitate
    3a. Spores hyaline

1. POLYPORUS SCHWEINITZII Fries. Pore surface greenish-brown, becoming dark reddish-brown with age; hyphae up to 17 μ in diam; setae absent. Brown root and butt rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Colo., Ariz., and N. Mex. Syn.: *sistotremoides* (Alb. & Schw.).
2. POLYPORUS TOMENTOSUS Fries. Pore surface light to dark yellowish-brown; context hyphae up to 7 μ in diam; setae straight; context up to 0.5 cm thick; on the ground attached to roots. White pocket rot of gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Ariz., and N. Mex.
3. POLYPORUS CIRCINATUS Fries. Setae hooked; context up to 2 cm thick; usually on base of dead or living trees; otherwise similar to *P. tomentosus*. White pocket rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., and Ariz. Syn.: *dualis* Peck.

3b. Spores pale brown

4. POLYPORUS PERENNIS L. ex Fries. Pores 2–4 per mm; context hyphae 4–8 μ in diam; spores 7–9 × 4–5 μ; upper surface tomentose to glabrous, dull, faintly zonate, often grayish, formed by a layer of upright, much-branched, antler-like hyphae. On the ground in Alaska, B. C., Sask., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz.

5. POLYPORUS CINNAMOMEUS Jacq. ex Fries. Pores 2–4 per mm; context hyphae 6–14 μ in diam; spores 6–9 × 5–6 μ; upper surface with silky, radially appressed fibrils. On the ground in B. C., Wash., Ore., Idaho, and Colo.

6. POLYPORUS MONTAGNEI Fries. Pores 0.5–2 mm in diam; context hyphae 6–15 μ in diam; spores 11–15 × 6–7.5 μ. On the ground in Wash. and Ore.

2b. Basidiocarps sessile, effused-reflexed or sometimes resupinate
4a. Spores hyaline

7. POLYPORUS DRYADEUS Pers. ex Fries. Basidiocarps up to 35 cm wide; spores subglobose, up to 7.5 μ in diam; setae often curved. White root and butt rot of *Tsuga* and a slash rot of other gymnosperms and angiosperms in B. C., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz.

8. POLYPORUS GILVUS (Schw.) Fries. Basidiocarps up to 12 cm wide; spores ellipsoid to ovoid, 4–5 × 3–3.5 μ; setae abundant, straight; pores 7–9 per mm. White rot of angiosperms in Wash., Ore., Idaho, Mont., Cal., Ariz., and N. Mex.

9. POLYPORUS RADIATUS Sow. ex Fries. Basidiocarps up to 5 cm wide; spores ellipsoid to ovoid, 4–5 × 3–3.5 μ; setae rare to absent; pores 4–5 per mm. White rot of angiosperms in Alaska, B. C., Wash., Ore., Idaho, and Mont.

4b. Spores brownish
5a. Context with a hard granular core

10. POLYPORUS DRYOPHILUS Berk. Spores ellipsoid to ovoid, 6.5–9 × 4.5–6 μ; setae none. White heartrot of living angiosperms, especially *Quercus*, in Ore., Cal., Ariz., and N. Mex. Syn.: *corruscans* Fries of American authors, *rheades* Pers. of American authors.

11. POLYPORUS VULPINUS Fries. Spores ellipsoid to ovoid, 4.5–7 × 3.5–5 μ; granular core slightly developed to absent; basidiocarps up to 10 cm wide. White rot of *Populus* in B. C., Wash., Idaho, Mont., and Colo.

5b. Context homogeneous
6a. Setal hyphae abundant

12. POLYPORUS GLOMERATUS Peck. Spores ellipsoid to ovoid, 4.5–7 × 3.5–5 μ. White heartrot of angiosperms in Ore., Idaho, Mont., and Wyo.

6b. Setal hyphae absent
7a. Upper surface strongly hispid

13. POLYPORUS HISPIDUS Bull. ex Fries. Spores dark brown, 8–9 × 6–8 μ; setae rare to absent; pores 1–3 per mm. White heartrot of angiosperms in Ore., Cal., Ariz., and N. Mex. Syn.: *hirsutus* (Scop.), *schini* (Brown).

14. POLYPORUS FARLOWII Lloyd. Spores pale yellowish to pale brown, 5.5–6 × 5–5.5 μ; setae scattered; pores 1–4 per mm. White heartrot of living angiosperms in Ariz. and N. Mex.

7b. Upper surface tomentose to glabrous

15. POLYPORUS CUTICULARIS Bull. ex Fries. Upper surface tomentose to fibrillose; spores pale to dark brown, ovoid, 7–8 × 6–6.5 μ; setae rare; pores 4–5 per mm. White rot of *Acer* in B. C., Wash., Cal., Utah, Ariz., and N. Mex.

16. POLYPORUS MUNZII Lloyd. Upper surface tomentose or becoming glabrous; spores dark brown, ellipsoid to subglobose, 6.5–8 × 4.5–6 μ; setae rare; pores 2–3 per mm. White rot of *Salix* in Cal., Utah, and Ariz.

17. POLYPORUS TEXANUS (Murr.) Sacc. & Trott. Upper surface tomentose, becoming glabrous; spores light brown, ellipsoid, 7–10 × 5–7 μ; setae none; pores 2–3 per mm. White heartrot of living angiosperms in Ariz.

1b. Context white to brightly colored or pale brownish, not darkening in KOH solution
8a. Basidiocarps stipitate (for 8b, see No. 48)
9a. Spores rough

18. POLYPORUS BERKELEYI Fries. Spores echinulate, amyloid, 7–8 × 6–7 μ; upper surface yellowish to tan. On ground under angiosperms in B. C., Wash., Ore., Idaho, and Mont.

19. POLYPORUS MONTANUS (Quél.) Ferry. Spores echinulate, amyloid, 6–7 × 5–6 μ; upper surface purplish-brown. On the ground under gymnosperms in B. C., Wash., Idaho, Mont., and Cal.

20. POLYPORUS GRISEUS Peck. Spores tuberculate, 5–6 × 3.5–5 μ; upper surface grayish or slightly olivaceous. On the ground in Wash., Ore., Idaho, and Mont. Syn.: *subsquamosus* Fries.

21. POLYPORUS SYLVESTRIS Overh. Spores appearing minutely spiny because of a pitted exospore, 10–14 × 7–11 μ; upper surface greenish-yellow. On the ground in B. C., Wash., and Idaho.

9b. Spores smooth
10a. Spores broadly ellipsoid to globose
11a. Spores conspicuously apiculate, more or less tear-shaped

22. POLYPORUS ELLISII Berk. Upper surface yellowish-green; spores 8–11 × 5–6 μ. On the ground under gymnosperms in Wash., Idaho, and Ariz.

23. POLYPORUS PES-CAPRAE Pers. ex Fries. Upper surface dark brown or reddish-brown; spores 8–10 × 6–6.5 μ. On the ground in Wash., Ore., and Idaho. Syn.: *oregonensis* (Murr.).

11b. Spores ovoid to ellipsoid, apiculus not conspicuous
12a. Basidiocarps fleshy, drying cheesy to rigid
13a. Spores up to 9 μ long

24. POLYPORUS SKAMANIUS Murr. Spores 8–9 × 5.5–6 μ. On the ground in Wash.

13b. Spores 3–5 μ long

25. POLYPORUS CRISTATUS Pers. ex Fries. Pileus yellowish to greenish when fresh; spores 4–5 × 3.5–5 μ. On the ground in Ore. and Idaho. Syn.: *flavovirens* Berk. & Rav.

26. POLYPORUS CONFLUENS Alb. & Schw. ex Fries. Pileus yellowish to tan when fresh, usually drying brick-red; spores 3–5 × 2.5–3 μ. On the ground in B. C., Wash., Ore., Idaho, Mont., and Colo.

27. POLYPORUS ILLUDENS Overh. Basidiocarp much branched with many small pilei; spores 4–5 × 3.5–4 μ; pileus color when fresh unknown, becoming brick red after drying. On the ground in Idaho. A similar fungus in Japan, *Polyporus dispansus* Lloyd, is bright yellow when fresh.

28. POLYPORUS OVINUS Schaeff. ex Fries. Pileus whitish when fresh, drying yellowish or olivaceous; spores 3–4 × 2.5–3 μ. On the ground in Alta., Wash., Ore., Idaho, Mont., and Colo.

29. POLYPORUS FLETTII Morse. Pileus grayish-blue when fresh, drying brick-red. On the ground in Wash.

12b. Basidiocarps tough, fibrous to corky when fresh

30. POLYPORUS BIENNIS (Bull. ex Fries) Fries. Basidiocarps stipitate to sessile; pilei usually solitary; context duplex; basidiospores 4–6 × 3.5–5 μ; subglobose chlamydospores up to 8.5 μ in diam present in context. On ground or on angiosperms in B. C., Wash., Ore., and Mont. Syn.: *balloui* Lloyd, *distortus* (Schw.).

31. POLYPORUS FRONDOSUS Dicks. ex Fries. Pilei many on a much branched stipe; individual pilei up to 7 cm wide; pores 2–4 per mm; spores 6–8 × 4–5 μ. On the ground under angiosperms in Wash., Idaho, and Mont.
32. POLYPORUS GIGANTEUS Pers. ex Fries. Pilei several on a much branched stipe; individual pilei up to 15 cm wide; pores 4–7 per mm; spores 6–7 × 4.5–6 μ. On the ground in Idaho.

10b. Spores cylindrical, narrowly ellipsoid or fusiform
14a. Spores mostly over 10 μ long

33. POLYPORUS TUBERASTER Jacq. ex Fries. Basidiocarps developing from a large, black, perennial, underground sclerotium; upper surface glabrous or slightly scaly. Under *Populus* in B. C., Alta., and Sask. Syn.: *tuckahoe* (Güss.).
34. POLYPORUS SQUAMOSUS Mich. ex Fries. Basidiocarps on wood; upper surface usually scaly; stipe black at the base. White rot of angiosperms in Wash., Idaho, Mont., and Colo. Syn.: *mcmurphyi* Murr.
35. POLYPORUS DECURRENS Underw. Upper surface scaly, drying yellowish- to reddish-brown; tubes decurrent; stipe reticulate. On the ground in Cal.
36. POLYPORUS HIRTUS Quél. Upper surface grayish to purplish-brown, usually tomentose or scurfy; pileus up to 12 cm wide. On the ground under gymnosperms in B. C., Wash., Ore., Idaho, Cal., Colo., and Ariz. Syn.: *hispidellus* Peck.
37. POLYPORUS CRYPTOPUS Ell. & Barth. Pileus up to 3 cm wide. On the ground, apparently attached to dead grass roots, in Wash., Idaho, Mont., and Colo.

14b. Spores less than 10 μ long
15a. Stipe black at the base

38. POLYPORUS ELEGANS Bull. ex Fries. Upper surface pale tan, weathering to white. White rot of angiosperms, occasionally gymnosperms, in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., and Ariz.
39. POLYPORUS VARIUS Fries. Upper surface pale brownish with light colored radial striations. White rot of angiosperms in Alta., Wash., Ore., Idaho, Wyo., Cal., Utah, Colo., and Ariz.
40. POLYPORUS MELANOPUS Fries. Upper surface reddish-brown to blackish; stipe long and rootlike. On the ground in Alaska, B. C., Alta., Sask., Wash., Idaho, and Mont. Syn.: *subradicatus* (Murr.).
41. POLYPORUS PICIPES Fries. Upper surface light chestnut brown to blackish. On angiosperms and gymnosperms in Alaska, B. C.,

Alta., Sask., Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *fissus* Berk.

15b. Stipe not black at the base
16a. Pores more or less diamond-shaped, usually radially aligned (see also no 247, *Favolus alveolaris*)

42. POLYPORUS ARCULARIUS Batsch ex Fries. Pileus up to 2.5 cm wide; upper surface often squamulose; margin usually ciliolate; spores 7–11 μ long. White rot of angiosperms in B. C., Wash., Ore., Idaho, Mont., Colo., Ariz., and N. Mex.

43. POLYPORUS BRUMALIS Pers. ex Fries. Pileus up to 6 cm wide; upper surface bronze to purplish-brown, short-hispid; margin often fringed or ciliolate; spores 6–7 μ long. White rot of angiosperms in B. C., Sask., Wash., Ore., Idaho, and Mont. Syn.: *polyporus* (Retz).

16b. Pores circular to angular, not radially elongated

44. POLYPORUS UMBELLATUS Pers. ex Fries. Pilei many on a much branched stipe. On the ground in Wash., Idaho, and Mont.

45. POLYPORUS FLORIFORMIS Quél. Basidiocarps laterally substipitate or in a rosette, often petal-like; taste bitter. On gymnosperms in Wash., Ore., Idaho, Cal., Colo., and Ariz.

46. POLYPORUS OSSEUS Kalchbr. Basidiocarps laterally substipitate; taste mild; becoming very hard on drying. On gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *zelleri* Murr.

47. POLYPORUS BETULINUS Bull. ex Fries. Basidiocarps laterally substipitate, up to 25 cm wide; upper surface with a distinct pellicle. On *Betula* in Alaska, B. C., Alta., Wash., Idaho, and Mont.

8b. Basidiocarps sessile, effused-reflexed or sometimes resupinate
17a. Spores ellipsoid to subglobose (for 17b, see No. 59)
18a. Clamp connections or septa abundant on principal context hyphae
19a. Basidiocarps yellowish-brown; tissue turning violaceous and then hyaline in KOH solution

48. POLYPORUS NIDULANS Fries. Context hyphae with abundant clamp connections; spores 3–4 × 2–3 μ. On angiosperms and gymnosperms in B. C., Wash., Idaho, and Ariz. Syn.: *rutilans* (Pers.).

19b. Basidiocarps white to brightly colored
20a. On incense cedar only; basidiocarps up to 25 cm thick

49. POLYPORUS AMARUS Hedgcock. Context hyphae up to 9 μ in diam; spores 6–8.5 × 3.5–5 μ. Brown pocket rot of *Libocedrus* in Ore. and Cal.

20b. On various gymnosperms and angiosperms; basidiocarps usually less than 5 cm thick
21a. Cystidia or cystidioles present; on gymnosperms

50. POLYPORUS CUNEATUS (Murr.) Zeller. Basidiocarps elongated, effused-reflexed to resupinate; pores 3–4 per mm; hyphae septate; cystidia capitately incrusted. White rot of *Thuja* in Alaska, B. C., Wash., Ore., Idaho and Mont. Syn.: *washingtonensis* (Murr.).

51. POLYPORUS CANADENSIS Overh. Basidiocarps usually dimidiate, sometimes substipitate; pores 6–9 per mm; upper surface grayish or mouse-colored; cystidioles inconspicuous, imbedded or barely projecting. On gymnosperms in Wash., Ore., Idaho, and Mont.

21b. Cystidia or cystidioles absent; on angiosperms

52. POLYPORUS DELECTANS Peck. Pores 1–2 per mm; spores subglobose, 5.5–6.5 × 5–5.5 μ. White rot of angiosperms in B. C., Ore., and Mont.

53. POLYPORUS GALACTINUS Berk. Pores 3–5 per mm; spores short-ellipsoid to ovoid, 4–4.5 × 3–3.5 μ. White rot of angiosperms in B. C., Wash., Ore., and Mont.

54. POLYPORUS SPUMEUS Sow. ex Fries. Pores 2–4 per mm; spores ovoid to subglobose, 5–7 × 3.5–4.5 μ. Heartrot of angiosperms in B. C., Wash., Idaho, Mont., and Colo.

18b. Clamp connections or simple septa absent or very rare on principal context hyphae
22a. Pileus bright orange; pore surface sulfur yellow

55. POLYPORUS SULPHUREUS Bull. ex Fries. Context hyphae profusely branched, up to 12 μ in diam; spores ellipsoid to ovoid, 5–7.5 × 4–5 μ. Brown cubical heartrot of gymnosperms in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., and Cal. Syn.: *speciosus* (Batt.).

22b. Pileus and pore surface whitish to tan
23a. Basidiocarps large, thick; spores up to 5 μ wide

56. POLYPORUS OBTUSUS Berk. Context duplex, soft-spongy above; pores 1–3 per mm. White heartrot of angiosperms, especially *Quercus*, in Ore., Mont., Ariz., and N. Mex. Syn.: *unicolor* (Schw.).

57. POLYPORUS SPRAGUEI Berk. & Curt. Context homogeneous, rigid; pores 3–6 per mm. Brown heartrot of butt and roots of *Acer* in Wash. and Ore.

23b. Basidiocarps small, thin; spores up to 2.5 μ wide

58. POLYPORUS SEMISUPINUS Berk. & Curt. Upper surface often appearing cartilaginous on drying. White rot of angiosperms in

B. C., Wash., Idaho, Mont., Colo., and Ariz. Resupinate specimens on gymnosperms, indistinguishable morphologically but culturally different, appear to be referable to *Poria byssina* (Pers.) Rom.

17b. Spores cylindrical to cylindric-ellipsoid
24a. Clamp connections or septa abundant in the principal context hyphae (for 24b, see No. 85)
25a. Principal context hyphae with simple septa, clamps lacking
26a. Upper surface and context white

59. POLYPORUS TULIPIFERAE (Schw.) Overh. Pore surface white, rapidly becoming hydnoid; conspicuous cystidia present. White rot of angiosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Utah, and N. Mex.

60. POLYPORUS BRESADOLAE (Bourd. & Galz.) Lowe. Pore surface purplish, remaining poroid; cystidia absent. White rot of *Pinus* and *Pseudotsuga* in Ariz.

26b. Entire basidiocarp brightly colored

61. POLYPORUS MOLLIS Pers. ex Fries. Pinkish-brown; cystidia lacking; spores 4–5 × 1–1.5 μ. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Wyo., Cal., Colo., Ariz., and N. Mex. Syn.: *pini-ponderosae* Long.

62. POLYPORUS ALBOLUTEUS Ell. & Everh. Orange; pores 1 mm or more in diam; spores 7.5–10 μ long; cystidia up to 65 μ long; usually resupinate. Brown rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Utah, Colo., and Wyo.

63. POLYPORUS FIBRILLOSUS Karst. Orange; pores 2–3 per mm; spores 5–6 μ long; cystidia 20–35 μ long; usually pileate. Brown rot of gymnosperms in Alaska, B. C., Sask., Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *aurantiacus* Peck.

25b. Principal context hyphae with clamp connections
27a. Basidiocarps very small, not over 1 cm in any dimension

64. POLYPORUS MINUSCULOIDES (Pilát) Lowe. Basidiocarps usually pendent, often consisting of only a few tubes; spores 4–5.5 × 2–2.5 μ; taste bitter. On very rotten log of *Pseudotsuga* in Wash.

27b. Basidiocarps becoming larger
28a. Pore surface becoming smoky-gray to reddish-purple

65. POLYPORUS ADUSTUS Willd. ex Fries. Basidiocarps usually less than 1 cm thick; not fragrant; tramal tissue pale brownish in KOH; dark layer at base of tubes usually distinct. White mottled rot of angiosperms, rarely gymnosperms, in Alaska, B. C., Alta., Sask.,

Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *crispus* Pers. ex Fries.

66. POLYPORUS FUMOSUS Pers. ex Fries. Basidiocarps usually more than 1 cm thick, fragrant; tramal tissue hyaline in KOH; dark layer at base of tubes lacking or indistinct. White rot of angiosperms in B. C., Wash., Ore., Idaho, Mont., and Cal.

67. POLYPORUS DICHROUS Fries. Pore surface flesh-colored to reddish-purple; gelatinous layer between tubes and upper context. White rot of angiosperms and gymnosperms in Alaska, B. C., Sask., Wash., Ore., Idaho, Mont., Cal., Colo., Ariz., and N. Mex.

28b. Pore surface white to yellowish or buff
29a. Basidiocarps whitish, becoming reddish-brown on bruising or drying

68. POLYPORUS SUBCARTILAGINEUS Overh. Context with gelatinous layer; spores 4–6 × 2–3 μ. On gymnosperms in Mont.

69. POLYPORUS LAPPONICUS Rom. Context homogeneous; spores 8–11 ×3–3.5 μ; cystidia large, conspicuous; upper surface often hispid. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Wyo., and Colo. Syn.: *ursinus* Lloyd.

70. POLYPORUS FRAGILIS Fries. Context homogeneous; spores 4–5 × 1.5–2.5 μ; cystidia absent; upper surface tomentose. Brown rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *sensibilis* (Murr.).

29b. Basidiocarps drying whitish, tan, or buff
30a. Pores large, 2–4 per mm

71. POLYPORUS BIFORMIS Fries. Hymenophore often becoming irpiciform; spores 6–8 × 2–2.5 μ. Yellowish rot of angiosperms in B. C., Ore., Idaho, Mont., Cal., Ariz., and N. Mex.

72. POLYPORUS BOREALIS Fries. Spores cylindric-ellipsoid, 5–7 × 3–4 μ; cystidia abundant. White mottled rot of gymnosperms, especially *Tsuga*, in Alaska, B. C., Wash., Ore., Idaho, Mont., Wyo., Colo., and Ariz. Syn.: *pacificus* Kauffm.

73. POLYPORUS UNDOSUS Peck. Spores allantoid, 4–5.5 × 1.5–2 μ; context tough; margin usually undulate. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *pseudotsugae* (Murr.).

74. POLYPORUS LEUCOSPONGIA Cooke & Harkn. Spores allantoid, 4.5–6 × 1–1.5 μ; context soft and cottony; margin partially enclosing pore surface. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Wyo., Nev., Utah, and Colo.

30b. Pores smaller, usually 4–7 per mm
31a. Upper surface dark reddish-brown, often rugose

75. POLYPORUS RESINOSUS Schrad. ex Fries. Context pale brown, up to 2 cm thick; tubes separated from context by a black layer; spores 5–7 × 1.5–2 μ. Soft, yellowish, aromatic rot of angiosperms and gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *benzoinus* Fries, *juliginosum* (Scop.).

31b. Upper surface whitish, not rugose
32a. Tissue bitter (see also no. 45, *Polyporus floriformis*)

76. POLYPORUS GUTTULATUS Peck. Upper surface usually smooth with small circular depressions; spores cylindrical, 4–5 × 2–2.5 μ. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., and Ariz. Syn.: *substipitatus* Murr.

77. POLYPORUS IMMITIS Peck. Upper surface usually rough, with small black spots; spores cylindrical, 3.5–5 × 1.5–2 μ. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., and Ariz. Syn.: *albidus* Schaeff. ex Fries of American authors.

78. POLYPORUS TRABEUS Rostk. Gloeocystidia present; spores often curved, 4–8 × 1.5–2 μ. Brown rot of gymnosperms in Ariz. The application of the specific name is doubtful; this is the concept of Bourdot and Galzin.

32b. Tissue mild

79. POLYPORUS BALSAMEUS Peck. Spores short-cylindrical, straight, 3.5–5.5 × 2.5–3 μ; inconspicuous cystidia present, often rare. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., and Ariz. Syn.: *carbonarius* (Murr.), *crispellus* Peck.

80. POLYPORUS CUTIFRACTUS Murr. Spores short-cylindric, 4–5 × 2–3 μ; upper surface with a brownish gelatinous or cartilaginous cuticle. On angiosperms and gymnosperms in B. C., Wash., Ore., Mont., and Cal.

81. POLYPORUS ALBELLUS Peck. Spores cylindrical, slightly curved, 4–5 × 1.5–2 μ; context hyphae much branched, thick-walled, up to 8 μ in diam; upper surface with a distinct smooth pellicle. White rot of angiosperms in Alaska, B. C., Sask., Wash., Ore., Idaho, and Mont.

82. POLYPORUS TEPHROLEUCUS Fries. Similar to *P. albellus* but with a bitter taste, rarely branched hyphae, and associated with a brown rot. On angiosperms in Mont. and Ariz. This is the concept of Overholts (**1953**).

83. POLYPORUS CAESIUS Schrad. ex Fries. Spores allantoid, 4–5 × 1–1.5 μ; context hyphae 2.5–4 μ in diam; basidiocarps more than 2 mm thick, with a bluish tinge. Brown rot of gymnosperms and angiosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz.

84. POLYPORUS PERDELICATUS Murr. Basidiocarps usually less than 2 mm thick, white; spores allantoid, 3.5–5 × 1–1.5 μ. On gymnosperms in B. C., Wash., Ore., Idaho, Mont., and Cal.

24b. Clamp connections or septa lacking or very rare in the principal context hyphae
33a. Tubes enclosed by a volva except for a small basal opening

85. POLYPORUS VOLVATUS Peck. Spores cylindrical, 7–11 × 3–4 μ. Superficial white saprot of recently killed gymnosperms in B. C., Alta., Wash., Ore., Idaho, Mont., Cal., Nev., Utah, Colo., and Ariz.

33b. Tubes not enclosed by a volva
34a. Basidiocarps reddish-orange

86. POLYPORUS CINNABARINUS Jacq. ex Fries. Spores short-cylindrical, straight or slightly curved, 4.5–5.5 × 2.5–3 μ; hyphal pegs abundant. White rot of angiosperms, rarely gymnosperms, in Alaska, N.W. Terr., B. C., Wash., Ore., Idaho, Mont., Cal., Utah, Colo., Ariz., and N. Mex.

34b. Basidiocarps not reddish-orange throughout
35a. Spores 1 μ or less wide

87. POLYPORUS AMORPHUS Fries. Context with a soft, fibrous upper layer and a firm cartilaginous lower layer. Brown rot of gymnosperms in B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., and Colo.

88. POLYPORUS SEMIPILEATUS Peck. Context homogeneous; slender hyphal pegs present. White rot of angiosperms in B. C., Wash., Ore., Idaho, Mont., and Cal.

35b. Spores 2–4.5 μ wide
36a. Basidiocarps with pale brownish context; spores 3–4.5 μ wide

89. POLYPORUS PLANELLUS (Murr.) Overh. Upper tomentum separated from lower context by a thin black layer; spores 8–11 × 3.5–4.5 μ. White rot of *Thuja* in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *planus* Peck.

90. POLYPORUS SUPINUS Swartz ex Fries. Context without black layers; upper surface glabrous; spores 9–10 × 3 μ. On *Carya* in Cal.

36b. Basidiocarps with whitish context; pore surface whitish to violaceous; spores 2–3 μ wide
37a. Basidiocarps tough-corky; dendritically branched hyphae conspicuous in context

91. POLYPORUS ANCEPS Peck. Spores 7–8 × 2.5–3 μ. White heartrot of living ponderosa pine and a slash rot of other gymnosperms in Alaska., B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Cal., Colo., Ariz., and N. Mex. Syn.: *stipticus* of American authors.

37b. Basidiocarps tough-fibrous; hyphae not dendritically branched
38a. Incrusted cystidia present; pore surface often violaceous

92. POLYPORUS ABIETINUS Dicks. ex Fries. Upper surface azonate, grayish, hirsute; pore surface often becoming irpiciform; context with a soft upper layer and a firm tough-fibrous lower layer; spores 6–7.5 × 2.5–3 μ. White saprot of gymnosperms in Alaska, N.W. Terr., B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex.

93. POLYPORUS PARGAMENUS Fries. Basidiocarps often tapering to a narrow base; upper surface zonate, glabrous; context homogeneous; spores 5–6 × 2–2.5 μ. White saprot of angiosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Utah, Colo., and N. Mex.

94. POLYPORUS SECTOR Ehrenb. ex Fries. Upper surface tomentose-velvety; pore surface pale brownish-purple. White rot of *Pseudotsuga* in Ariz.

95. POLYPORUS SUBCHARTACEUS (Murr.) Overh. Basidiocarps thick, not tapering to the base; pore surface remaining poroid; spores 8–9 × 2.5–3 μ. White rot of angiosperms in B. C., Idaho, Mont., Wyo., Utah, and Colo.

96. POLYPORUS VERSATILIS (Berk.) Rom. Context very thin; tubes up to 5 mm long; pores 1–2 per mm. White rot of gymnosperms in Ariz. Syn.: *rubricosa* (Bres.).

38b. Cystidia not present; pore surface white to buff

97. POLYPORUS VERSICOLOR L. ex Fries. Upper surface distinctly zonate with multicolored zones; soft, thin upper context separated from lower tough-fibrous context by a thin dark layer. White rot of angiosperms, rarely gymnosperms, in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *hirsutulus* Schw., *macounii* Lloyd.

98. POLYPORUS VELUTINUS Fries. Upper surface faintly zonate; context homogeneous. White rot of angiosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Utah, Colo., and Ariz. Syn.: *zonatus* Fries of American authors.

99. POLYPORUS HIRSUTUS Wulf. ex Fries. Upper surface azonate, strongly hirsute, grayish or with a brown margin. White rot of angiosperms in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *nigromarginatus* (Schw.).

100. POLYPORUS PUBESCENS Schum. ex Fries. Upper surface azonate, tomentose to almost glabrous, ivory to buff. White rot of angiosperms in Alaska, N.W. Terr., B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., and Cal.

II. PORIA Pers. ex S. F. Gray emend. Cooke

1a. Context some shade of brown and the tissue darkening in KOH solution (for 1b, see No. 114)

2a. Basidiocarp developed under the bark; spores colored in mass

101. PORIA ANDERSONI (Ell. & Everh.) Neuman. Spores sulphur-yellow in mass, yellowish under the microscope, 5–8 × 4–5.5 μ. White rot of angiosperms, usually *Quercus*, in Ore., Cal., and Ariz. Syn.: *leci* (Murr.), *xanthospora* (Underw.).

102. PORIA OBLIQUA (Pers. ex Fries) Karst. Spores yellowish in mass, hyaline to pale brown under the microscope, 8–10 × 6–7.5 μ. White rot of angiosperms in B. C., Sask., Idaho, and Mont.

2b. Basidiocarp developed on the surface of the substratum; spores white in mass

3a. Trama made up wholly or largely of setal hyphae

103. PORIA FERRUGINEOFUSCA Karst. Spores cylindrical, 1.5–2 μ wide; setal hyphae 3–5 μ in diam, ending by a right-angle bend into the pore area. White rot of gymnosperms in Alaska, B. C., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., and Colo. Syn.: *marginella* (Peck).

104. PORIA WEIRII Murr. Spores ovoid, 3–3.5 μ wide; setal hyphae 5–11 μ in diam, slanting outward into pore area. Yellow ring rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., and Wyo.

3b. Trama made up of ordinary hyphae

4a. Spores cylindrical

5a. Pores 4–6 per mm

105. PORIA FERREA (Pers.) Bourd. & Galz. Context firm, homogeneous. White rot of angiosperms and gymnosperms in Alaska, B. C., Sask., Wash., Ore., Idaho, Mont., and Cal. Syn.: *cylindrospora* Lloyd.

106. FOMES NIGROLIMITATUS (Rom.) Egel. Context soft, with black lines. See No. 190.

5b. Pores 1–4 per mm

107. TRAMETES CARBONARIA (Berk. & Curt.) Overh. Setae lacking; pores 1–2 per mm. See No. 216.

108. FOMES VITICOLA (Schw.) Lowe. Setae present; pores 2–4 per mm. See No. 189.

4b. Spores ellipsoid to globose
6a. Spores 5–8 μ in longest dimension

109. FOMES ROBUSTUS Karst. Perennial, becoming woody; pores 4–8 per mm; spores more or less globose. See No. 194.

110. PORIA SUBICULOSA (Peck) Cooke. Annual; soft; pores 2–3 per mm; spores short-oblong to oblong-oval. Rot unknown, on gymnosperms in B. C. and Colo.

6b. Spores ellipsoid to oval, rarely over 5 μ in greatest dimension

111. PORIA FERRUGINOSA (Schrad. ex Fries) Karst. Annual; pores 4–5 per mm; setae 25–45 μ long. White rot of angiosperms and gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Cal., Colo., and N. Mex.

112. FOMES IGNIARIUS (L. ex Fries) Kickx. Perennial; pores 7–10 per mm; setae 15–30 μ long. A common resupinate species on *Betula* has been referred to the resupinate form of *F. igniarius* (*Poria laevigata*), but it appears to differ in being markedly rimose and in producing a striking ring rot. See No. 195.

113. FOMES REPANDUS Overh. Perennial; pores 5–7 per mm; context soft; setae up to 24 μ long. See No. 197.

1b. Context and tubes white or brightly colored, not brown and tissue not blackening in KOH solution
7a. Basidia cruciately septate

114. APORPIUM CARYAE (Schw.) Teix. & Rogers. White rot of angiosperms in Yukon Terr., Wash., Idaho, Cal., and Colo. Syn.: *argillacea* (Cooke), *canescens* Karst.

7b. Basidia nonseptate; pores arising as papillae which open with age, the basidiocarp becoming poroid

115. POROTHELEUM FIMBRIATUM (Pers. ex Fries) Fries. White rot of angiosperms and gymnosperms in Mont., Cal., Colo., and Ariz.

7c. Basidia nonseptate; pores open and exposed from the first
8a. Context hyphae of one type (for 8b, see No. 155)
9a. Context hyphae septate (for 9b, see No. 132)
10a. Isolated hymenia produced at first at base of tubes, by radial extension outlining tubes where hymenia meet; tubes formed by downward extensions (cupulate habit)
11a. Spores 4–5 μ long

116. PORIA TARDA (Berk.) Cooke. Context hyphae 3–5 μ in diam; pore surface cream or pinkish. Rot probably white, of angiosperms in B. C., and Ariz. Syn.: *fatiscens* (Berk. & Rav.), *semitincta* (Peck).

117. PORIA RHODELLA (Fries) Cooke. Context hyphae 4–8 μ in diam; color extremely various. Rot probably white, of angiosperms and gymnosperms in Alaska, B. C., Wash., Ore., Mont., Cal., and Ariz. Syn.: *griseoalba* (Peck), *viridans* (Berk. & Br.).

11b. Spores 5–8 μ long

118. PORIA PURPUREA (Fries) Cooke. Pore surface purple, often dark red on drying; spores 1.5–2.5 μ wide. Rot probably white, of gymnosperms and occasionally of angiosperms in Alaska, Yukon Terr., B. C., Alta., Wash., Ore., Idaho, Mont., Cal., Nev., and Colo. The relation of this species to No. 60, *Pol. bresadolae*, is not yet clear; the type of *P. bresadolae* has context hyphae mostly 3–4 μ in diam and most American specimens are similar. *P. purpurea* may differ in having context hyphae 4–8 μ in diam, but the validity of this distinction is not yet adequately tested.

119. PORIA RETICULATA (Fries) Cooke. Pore surface white or grayish-white; spores 2.5–3.5 μ wide. Rot uncertain, probably white, of gymnosperms and rarely of angiosperms in Alaska, B. C., Alta., Wash., Colo., and Ariz.

10b. Tubes outlined on hyphal mat and formed by downward extension, the hymenium produced later
12a. Context hyphae 2–5 μ in diameter
13a. Cystidia present; pore surface white to cream

120. PORIA CORTICOLA (Fries) Cooke. Spores ellipsoid, 5–7 μ long. White rot of angiosperms and rarely of gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., and Colo. Syn.: *vicina* Bres.

121. PORIA SIMILIS Bres. Spores oval to subglobose, 2.5–5 μ in greatest dimension; cystidia large; tubes fragile or papery. White rot of angiosperms in B. C., Wash., Ore., Idaho, Mont., Cal., and Ariz.

122. POLYPORUS CUNEATUS (Murr.) Zeller. Spores subglobose, 3.5–5 μ in greatest dimension; cystidia small; tubes soft but tough. On *Thuja*, see No. 50.

13b. Cystidia absent; pore surface colored

123. PORIA SPISSA (Schw.) Cooke. Pore surface orange, drying dark red; pores 6–8 per mm. Rot uncertain, brown by cultural evidence but specimens associated with a white rot of angiosperms and gymnosperms in Wash., Ore., Cal., and Ariz.

124. PORIA TAXICOLA (Pers.) Cooke. Pore surface pink to dark red; pores 4 per mm. Brown rot of gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., and Colo. Syn.: *rufa* (Schrad. ex Fries).

125. PORIA TERRESTRIS (DC. ex Fries) Cooke. Pore surface drying variously pink or olivaceous; pores 2–3 per mm; basidiocarp soft-fibrous. Rot unknown, on gymnosperms in Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *parksii* Murr.

12b. Context hyphae mostly 5–8 μ or more in diameter
14a. Pores 1–4 per mm

126. PORIA COCOS (Schw.) Wolf. Context hyphae 3–16(–29) μ in diam; spores 6–11 μ long; cystidia absent. Brown rot of gymnosperms in Alta., Sask., Wash., Ore., Idaho, and Cal.

127. PORIA AMBIGUA Bres. Context hyphae 3–8 μ in diam; spores 5–6 μ long; cystidia when present small; capitate-incrusted. White rot of angiosperms in B. C., Alta., Wash., Ore., and Cal.

128. POLYPORUS TULIPIFERAE (Schw.) Overh. Context hyphae 4–6 μ in diam; spores 5–6 μ long; cystidia elongated, incrusted. On angiosperms, see No. 59.

14b. Pores 4–7 per mm

129. PORIA SANGUINOLENTA (Alb. & Schw.) Cooke. When fresh white, tender, reddening on bruising, usually drying dark red and very thin; spores subglobose, 5–7 × 4–5.5 μ. Specimens which do not discolor are referred to var. *expallescens* (Karst.) Sacc. Uniform white rot of gymnosperms and angiosperms in B. C., Wash., Ore., Idaho, Mont., and Cal. Syn.: *decolorans* (Schw.), *terrestris* of many authors.

130. PORIA UNDATA (Pers.) Bres. White when fresh, cartilaginous, watery where bruised, drying pale brown, often thick; spores 4–5 × 4 μ. White pocket rot of angiosperms in Alaska, B. C., Wash., and Idaho.

131. PORIA NIGRESCENS Bres. Pinkish when fresh, watery where bruised, drying pale brown, often thick, with successively receding layers of tubes; spores 4–5.5 × 3–4 μ. Uniform white rot of angiosperms and gymnosperms in Alaska, B. C., Wash., Idaho, and Cal.

9b. Context hyphae with at least some clamp connections
15a. Spores ellipsoid to globose (for 15b, see No. 144)
16a. Spores becoming brown at maturity

132. PORIA INCRASSATA (Berk. & Curt.) Burt. Pore surface at first grayish, darkening with age. Brown rot of gymnosperms, especially of structural timbers, in B. C., Ore., Idaho, and Cal.

16b. Spores hyaline
17a. Basidiocarp soft-membranous
18a. Spores 5–7 μ long

133. PORIA BOMBYCINA (Fries) Cooke. Color very variable, usually with some tint of purple. Brown rot of gymnosperms in Alaska, Wash., Idaho, Mont., Colo., and Ariz. Syn.: *coniferarum* Baxt., *fulvella* Bres.

18b. Spores not over 5 μ long
19a. Pore surface colored

134. PORIA ALBOLUTESCENS (Rom.) Egel. Usually drying more or less orange-yellow. Brown rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, and Colo.

19b. Pore surface white to cream colored

135. PORIA CANDIDISSIMA (Schw.) Cooke. Spores echinulate. White rot of angiosperms and gymnosperms in B. C., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *subtilis* (Schrad. ex Fries) of most authors.

136. PORIA MYCELIOSA Peck. Spores smooth, short-oblong to oval. White rot of gymnosperms and angiosperms in Alaska, B. C., Ore., Idaho, Mont., and Wyo.

137. PORIA MOLLUSCA (Pers. ex Fries) Cooke. Spores smooth, broadly oval to subglobose. White rot of gymnosperms and angiosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., and Cal.

17b. Basidiocarp waxy, hard, or fragile when dry
20a. Pore surface yellow, or orange to red

138. PORIA AUREA Peck. With large incrusted cystidia; pores 2–4 per mm. Rot probably brown, of gymnosperms in Alaska, B. C., Sask., and Ariz.

20b. Pore surface white to cream
21a. Taste bitter

139. PORIA ALBIPELLUCIDA Baxt. Cystidia absent; spores more or less globose; drying rigid, translucent. White rot of gymnosperms in Alaska., B. C., Wash., Ore., Idaho, Mont., Cal., Ariz., and N. Mex.

140. PORIA SERICEOMOLLIS (Rom.) Egel. Cystidia usually present and capitate-incrusted; spores oblong-ellipsoid; drying fragile, opaque. Brown rot of gymnosperms and angiosperms in N.W. Terr., B. C., Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *asiatica* (Pilát).

21b. Taste mild

141. PORIA ANEIRINA (Sommerf.) Cooke. Pores 1–3 per mm; spores usually 5–6 μ long. White rot of angiosperms, usually *Populus*, in Alaska, B. C., Sask., Wash., Idaho, Mont., Wyo., Colo., and Ariz.

142. PORIA VERSIPORA (Pers.) Rom. Pores 3–4 per mm; hyphal clamps small, inconspicuous; spores 2.5–4 μ wide. White rot of angiosperms and gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., and Cal.

143. PORIA CARNEGIEA Baxt. Pores 3–4 per mm; hyphal clamps large, conspicuous; spores 2–3 μ wide. White rot of *Carnegiea* in Ariz.

15b. Spores cylindrical
22a. Spores 0.5–1 (rarely to 1.5) μ wide
23a. Pores 2–4 per mm

144. PORIA LATITANS Bourd. & Galz. Mild; spores 0.5–0.75 μ wide; cystidia present. White rot of gymnosperms and angiosperms in Ariz.

145. PORIA SUBVERMISPORA Pilát. Bitter; spores 1–1.5 μ wide; cystidia lacking. White rot of gymnosperms and angiosperms in Ariz. Syn.: *notata* Overh.

23b. Pores 4–7 per mm

146. PORIA PANNOCINCTA (Rom.) Lowe. Pore surface yellowish; bitter; with a distinct line below the tubes. Rot probably white, of angiosperms in N.W. Terr., B. C., Sask., Idaho, and Mont. Syn.: *tacamahacae* Baxt., *zameriensis* (Pilát).

147. PORIA VULGARIS (Fries) Cooke. Whitish; mild; context homogeneous, sometimes with a firmer layer next to the substratum; cystidia absent. Rot probably brown, of gymnosperms in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., Utah, and Ariz. The application of this specific name has been very variable; here used in the sense of Lowe (1946).

148. PORIA ŠIMANI Pilát. Whitish; bitter; context homogeneous; cystidia hyphoid, capitate-incrusted. Brown rot of gymnosperms in Ariz.

22b. Spores 1.5–2.5 μ wide
24a. Basidiocarps distinctly colored

149. PORIA SALMONICOLOR (Berk. & Curt.) Cooke. Orange-yellow, reddish or blackening on drying; context hyphae 4–7 μ in diam. Rot uncertain, on gymnosperms in B. C., Wash., and Idaho. Syn.: *rubens* Overh. & Lowe.

150. PORIA CARNICOLOR Baxt. Pink, often fading on drying; context hyphae 2–4.5 μ in diam. Brown rot of gymnosperms in B. C., Wash., Idaho, Mont., and Colo. *P. microspora* is very similar, perhaps identical, having faded on drying. This fungus occurs in Europe where it has been named *P. placenta* (Fries) Cooke by Lundell, and *P. incarnata* (Fries) Cooke by Parmasto.

24b. Basidiocarps white to cream or tan
25a. Spores 4–5 μ long

151. PORIA RIMOSA Murr. Pores 5–6 per mm; cystidia present. White rot of *Juniperus* in Ore., Idaho, Ariz., and N. Mex.

152. PORIA MONTICOLA Murr. Pores 3–4 per mm; cystidia absent. Brown rot of gymnosperms in B. C. and Idaho.

25b. Spores 5–10 μ long

153. PORIA MAPPA Overh. & Lowe. Spores 7–10 × 2.5–3 μ. Brown rot of gymnosperms in B. C. and Idaho.

154. PORIA JOHNSTONII Murr. Cream-colored; spores 5–6 × 1.5–2 μ. White pocket rot of gymnosperms in Cal.

8b. Context hyphae of two or more types
26a. Spores ellipsoid to globose
27a. Spores amyloid, often echinulate

155. PORIA AVELLANEA Bres. Spores 3–4 × 2.5–4 μ. Rot unknown; on gymnosperms in Colo., previously misidentified as the following species.

156. PORIA LENTA Overh. & Lowe. Spores 5–6 × 4–5 μ. Rot unknown; on gymnosperms in B. C.

27b. Spores not amyloid, smooth
28a. Cystidia present

157. PORIA FIMBRIATELLA (Peck) Sacc. Pores 4 per mm; rhizomorphic; pore surface white to pale cream; spores more or less globose, 2.5–3 μ in diam. Rot probably white, of angiosperms in Alaska, Yukon Terr., Wash., and Cal.

158. PORIA RADULA (Pers. ex Fries) Cooke. Pores 2–4 per mm; rhizomorphic; pore surface deep cream; spores short oblong to oval, 2.5–4.5 × 2–3 μ. White rot of angiosperms in Wyo. and Colo.

159. PORIA EUPORA (Karst.) Cooke. Pores 6–8 per mm; not rhizomorphic. White rot of angiosperms in B. C., Wash., and Idaho. Syn.: *attenuata* (Peck).

28b. Cystidia lacking
29a. Basidiocarps coriaceous (see also No. 58, *P. semisupinus*)

160. PORIA SUBACIDA (Peck) Sacc. Spores rounded at ends; pores 2–4 per mm. Stringy white rot of gymnosperms and angiosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *colorea* Overh. & Englerth.

161. PORIA TENUIS (Schw.) Cooke. Spores distinctly truncate at one end; pore surface whitish, the pores 2–4 per mm. White rot of angiosperms and rarely of gymnosperms in Mont., Colo., and Ariz. Var. *pulchella* (Schw.) Lowe is yellow when fresh, usually fading and indistinguishable on drying; in B. C., Mont., Wyo., Cal., and Colo.

162. FOMES UNITUS (Pers.) Lowe. White; pores 6–8 per mm. See No. 210.

29b. Basidiocarps soft, drying soft or rigid and fragile
30a. Rhizomorphic

163. PORIA RADICULOSA (Peck) Sacc. Yellow. Brown rot of gymnosperms in Wash., Idaho, Cal., and Ariz. Specimens from Washington and Idaho have stouter rhizomorphs than usual, and the determination is not wholly certain. Syn.: *luteofibrata* Baxt.

164. PORIA VAILLANTII (Fries) Cooke. White. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Cal., and Ariz.

165. PORIA OVERHOLTSII Pilát. Pores 2–4 per mm; drying fragile; context hyphae 1–3 μ in diam. White rot of angiosperms in Ariz.

30b. Rhizomorphs lacking

166. PORIA CRASSA (Karst.) Sacc. Pores 5–6 per mm; drying waxy; context hyphae 2–5 μ in diam. Brown rot of gymnosperms in Alaska, B. C., and Mont.

26b. Spores cylindrical
31a. Spores mostly more than 5 μ long
32a. Cystidia present

167. PORIA RIXOSA Karst. Pore surface pinkish, the pores 4–6 per mm. White rot of gymnosperms in B. C., Alta., Wash., Idaho, Mont., and Colo.

168. PORIA ZONATA Bres. Pore surface whitish, the pores 1–2 per mm. White rot of gymnosperms in B. C., Wash., Idaho, Mont., Cal., and N. Mex.

32b. Cystidia absent
33a. Taste bitter
34a. Pores 4–7 per mm

169. PORIA FEROX Long & Baxt. Context hyphae nearly all alike, with rare clamps, 2–3(–4) μ in diam. Brown rot of *Juniperus* in Ariz. and N. Mex., on *Arbutus* in B. C. and Cal., and on *Pseudotsuga* in Wash.

170. PORIA STENOSPORA Overh. Context hyphae rarely branched, clamped, 3–5 μ in diam, with much branched outgrowths. Brown rot of *Pseudotsuga* in Wash., known only from the type.

34b. Pores 2–4 per mm

171. PORIA RANCIDA Bres. Tubes and context drying waxy-fragile. Brown rot of gymnosperms and angiosperms in Colo.

172. TRAMETES SERIALIS Fries. Tubes and context drying corky-fibrous. This is *Poria callosa* (Fries) of many authors. See No. 225.

33b. Taste mild (see also No. 114, *A. caryae*)

173. PORIA CARBONICA Overh. Context hyphae 4–10 μ in diam; basidiocarp hard when dry. Brown rot of gymnosperms in B. C., Wash., Ore., Idaho, Mont., and Cal.

174. PORIA ALBOBRUNNEA (Rom.) Baxt. Context hyphae 2–4 μ in diam; basidiocarp soft, tough, with a brownish layer next to the substratum. Brown rot of gymnosperms in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., and Colo. Syn.: *dichroa* Bres.

175. PORIA CINERASCENS Bres. Drying white, the tubes fragile; spores 1.5–2.5 μ in diam. White rot of gymnosperms in Alaska, B. C., Sask., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *subavellanea* Murr., *subfuscoflavida* (Rostk.) of American determinations.

176. PORIA CRUSTULINA Bres. Drying more or less yellowish, rigid and tough; spores 2.5–3 μ in diam. White rot of gymnosperms in Alaska, B. C., Idaho, Mont., Wyo., and Colo. Syn.: *chromatica* Overh.

31b. Spores not over 5 μ long
35a. Pore surface often yellow when fresh or when dried; extremely bitter; brittle when dry

177. PORIA XANTHA (Fries ex Lind) Cooke. Pores 5 per mm. Brown rot of gymnosperms and angiosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., Colo., and Ariz.

178. PORIA ALPINA Litsch. Pores 3–4 per mm. Brown rot of gymnosperms in Ore. and Idaho. Although differing from *P. xantha* mostly in its larger pores, it is quite different culturally. No fertile specimens have yet been seen.

35b. Pore surface white to cream or pinkish; usually mild, more or less tough
36a. Pores 1–4 per mm

179. PORIA VAPORARIA (Pers. ex Fries) Cooke. Pores 1–2 per mm. Brown rot of gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., and Colo. Much western material is filed under the name of *P. sinuosa* (Fries) Cooke which, according to Lundell and Nannfeldt (**1936**, no. 248), is a synonym.

180. PORIA LUTEOALBA (Karst.) Sacc. Pores 3–4 per mm; annual; cystidia large, incrusted; mild. Brown rot of gymnosperms in Ore., Idaho, Mont., and Ariz. Syn.: *sinuascens* Pilát.

36b. Pores 4–7 per mm
37a. Spores 0.5–1 μ wide

181. PORIA SUBINCARNATA (Peck) Murr. Pores 5–7 per mm; tubes in one layer. White rot of gymnosperms in B. C., Ore., Idaho, Mont., Wyo., Cal., and Colo.

182. PORIA STELLAE Pilát. Pores 4–5 per mm; tubes in old specimens layered. White rot of gymnosperms in B. C., Ore., Idaho, Mont., and Wyo.

37b. Spores at least 1 μ and usually 1.5 μ or more wide
38a. Rhizomorphic; spores 2.5–3.5 μ long

183. PORIA ALUTACEA Lowe. Membranous-tough. White rot of angiosperms and gymnosperms in B. C., Wash., Ore., Idaho, and Mont.

38b. Not rhizomorphic; spores 3.5–4.5 μ long

184. PORIA SITCHENSIS Baxt. Perennial; resinously bitter. Rot uncertain, on gymnosperms in Alaska, B. C., Ore., Idaho, Cal., Ariz., and N. Mex. The identity of this species is not wholly established; this concept is based upon For. Path. No. 109116 at Beltsville, Md., a specimen determined by Dr. Baxter.

185. PORIA LENIS (Karst.) Sacc. Annual, mild, soft but tough; spores lunate, at least in part; context hyphae 1.5–2.5 μ in diam. Rot uncertain, probably white, of gymnosperms and angiosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Wyo., Cal., Colo., and Ariz.

186. PORIA SEQUOIAE Bonar. Annual, mild; spores cylindric-ellipsoid; context hyphae 3–5 μ in diam. Brown rot of *Sequoia* in Calif. The original material is composed of several species and the type is a poor specimen. The actual identity is not wholly clear; the species is very similar to *P. cinerascens* and *P. monticola*.

III. FOMES (Fries) Kickx

1a. Context tissue brown (for 1b, see No. 203)
2a. Upper surface with a thick, hard crust; context tissue pale brown, not darkening in KOH solution

187. FOMES FOMENTARIUS (L. ex Fries) Kickx. Spores 17–20 × 5–6 μ; pores 3–4 per mm. White rot of angiosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, and Mont.

188. FOMES SCLERODERMEUS (Lév.) Cooke. Spores 8–13 × 3–4 μ; pores 4–6 per mm. White rot of angiosperms in Ariz. Syn.: *marmoratus* (Berk. & Curt.).

2b. Upper surface without a thick, hard crust; context tissue yellowish-brown to dark reddish-brown, darkening in KOH solution
3a. Spores hyaline
4a. Spores cylindrical

189. FOMES VITICOLA (Schw.) Lowe. Context homogeneous; setae subulate, up to 75 μ long; spores uniform in diameter. White rot of gymnosperms and angiosperms in Alaska, Yukon Terr., B. C., Alta., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz. Syn.: *isabellina* (Fries), *setosus* (Weir), *tenuis* Karst.

190. FOMES NIGROLIMITATUS (Rom.) Egel. Context with one or more thin, black layers; setae subulate to ventricose, up to 35 μ long; spores attenuated at one end. Large white pocket rot of gymnosperms in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, and Colo. Syn.: *putearius* Weir.

4b. Spores ellipsoid, ovoid, or subglobose
5a. Setae projecting up to 50 μ or more; pores 1–4 per mm

191. FOMES PINI (Thore ex Pers.) Lloyd. Setae abundant. White pocket rot of living gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *abietis* Karst., *piceinus* (Peck), *vorax* (Harkness).

192. FOMES OCCIDENTALIS Overh. Morphologically similar to *F. pini* but with rare, scattered setae. Uniform white heartrot of *Crataegus* in Wash., Ore., Idaho, Mont., and Utah.

5b. Setae projecting up to 35 μ or less, in some species very rare or absent; pores 4–8 per mm
6a. Setae projecting 20–35 μ

193. FOMES CONCHATUS (Pers. ex Fries) Gill. Spores ovoid, 5–6.5 × 4–4.5 μ; pores 6–8 per mm. Uniform white rot of angiosperms in B. C., Wash., Ore., Idaho, Mont., Wyo., and Colo.

6b. Setae projecting less than 20 μ, or absent
7a. Spores subglobose, up to 6 μ or more in diameter

194. FOMES ROBUSTUS Karst. Setae usually absent; spores up to 8.5 μ in diam; context bright yellowish-brown. White heartrot of angiosperms and gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *abramsianus* (Murr.), *hartigii* (Allescher and Schnabl), *punctata* (Fries).

195. FOMES IGNIARIUS (L. ex Fries) Kickx. Spores up to 6.5 μ in diam; basidiocarps becoming large, up to 20 cm in diam. White heartrot of many angiosperms in B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *arctostaphyli* Long, *laevigata* (Fries), *prunicola* (Murr.).

196. FOMES POMACEUS (Pers.) Lloyd. Spores up to 6.5 μ in diam; basidiocarps small, up to 5 cm wide. White heartrot of *Prunus* and *Crataegus* in Wash., Ore., Idaho, Mont., Wyo., Colo., and N. Mex. Syn.: *fulvus* (Scop. ex Fries).

7b. Spores ovoid, up to 5 μ long

197. FOMES REPANDUS Overh. Basidiocarps usually resupinate; setae rare; tube layers becoming brittle and difficult to section on drying; context homogeneous. White pocket rot of gymnosperms in B. C., Wash., Ore., Idaho, and Mont.

3b. Spores yellowish to dark brown
8a. Setae present

198. FOMES EVERHARTII (Ell. & Gall.) von Schrenk & Spauld. Spores dark reddish-brown; setae abundant to rare, up to 35 μ long. White heartrot of angiosperms, especially *Quercus*, in Ore., Idaho, Mont., Cal., Ariz., and N. Mex. Syn.: *praerimosus* (Murr.).

199. FOMES WEIRIANUS Bres. Spores pale yellowish-brown; setae infrequent, up to 60 μ long. White heartrot of angiosperms, especially *Juglans*, in Ariz. and N. Mex.

8b. Setae absent

200. FOMES RIBIS (Schum. ex Fries) Gill. Context duplex, with soft upper tissue separated by a thin black layer; spores 2.5–4 × 2.5–3 μ.

White heartrot of *Ribes* and *Lonicera* in Ore., Idaho, Mont., Wyo., Cal., and N. Mex.

201. FOMES ROBINEAE (Murr.) Sacc. & D. Sacc. Pores 5–8 per mm; context homogeneous; spores 4–5.5 × 3.5–5 μ; tissue sectioning easily. White heartrot of *Robinia* and *Prosopis* in Idaho, Ariz., and N. Mex. Syn.: *rimosus* (Berk.) Cooke of American authors.

202. FOMES BADIUS (Berk.) Cooke. Pores 2–5 per mm; context homogeneous; spores 5.5–7 × 4.5–6 μ; tissue brittle and difficult to section. White heartrot of *Prosopis* and *Acacia* in Ariz. and N. Mex.

1b. Context reddish-orange or yellowish-orange

203. FOMES DEMIDOFFII (Lév.) Cooke. Hymenophore persistently poroid; spores truncate, pale to dark brown, 7–9 × 5–7 μ. White heartrot of *Juniperus* in Ore., Idaho, Mont., Utah., Colo., Ariz., and N. Mex. Syn.: *carlei* (Murr.), *juniperinus* (von Schrenk).

204. FOMES TINCTORIUS Ell. & Ever. [*Echinodontium tinctorium* (Ell. & Everh.)]. Hymenophore poroid at first, soon becoming hydnoid; spores hyaline, becoming reddish-brown, smooth or minutely spiny, 7–8.5 × 6–7 μ; imbedded ventricose, thick-walled setae in subhymenial tissue. Brownish stringy or laminated heartrot of gymnosperms, especially *Tsuga* and *Abies*, in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Colo., Ariz., and N. Mex.

1c. Context rose-colored

205. FOMES ROSEUS (Alb. & Schw. ex Fries) Karst. Spores straight, 5–8 × 2–3 μ. Brown rot of gymnosperms in B. C., Alta., Ore., Idaho, Mont., Wyo., Utah, and Colo.

206. FOMES CAJANDERI Karst. Spores curved, 5–8 × 1.5–2.5 μ. Brown rot of gymnosperms in B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Utah, and Ariz. Syn.: *carnea* of American authors, *subrosea* (Weir).

1d. Context whitish, cream, or buff

9a. Pileus tomentose to hispid; incrusted cystidia present

207. FOMES NOBILISSIMUS (W. B. Cooke) Lowe. Basidiocarps becoming massive, up to 140 cm wide and weighing up to 136 kg; upper context composed of a thick layer of loosely interwoven, stiff, fiber-like aggregations of hyphae. Brown rot of *Abies* and *Tsuga* in Wash. and Ore.

208. FOMES CONNATUS (Weinm.) Gill. Basidiocarps up to 12 cm wide; upper surface finely tomentose to glabrous, often covered by moss. White heartrot of *Acer* in B. C. Syn.: *populinus* sense of Murrill.

9b. Pileus glabrous; incrusted cystidia absent
10a. Basidiocarps small, up to 5 cm wide

209. FOMES OHIENSIS (Berk.) Murr. Basidiocarps sessile; upper surface smooth, crustlike; spores truncate at one end, 11–16 × 6–8.5 μ. White rot of angiosperms in Wyo. and Ariz.

210. FOMES UNITUS (Pers.) Lowe. Basidiocarps usually resupinate; spores often truncate at one end, 4–7 × 2.5–5 μ. White rot of angiosperms in Wash., Ore., Idaho, Mont., Cal., and Colo. Syn.: *medulla-panis* (Pers.).

211. FOMES SCUTELLATUS (Schw.) Cooke. Basidiocarps sessile, less than 3 cm wide; spores cylindrical, rounded at both ends, 10–11 × 3–3.5 μ. White rot of *Alnus* and *Quercus* in B. C., Wash., Ore., Idaho, Mont., and Ariz.

10b. Basidiocarps becoming large, up to 15 cm or more wide

212. FOMES FRAXINOPHILUS (Peck) Cooke. Basidiocarps effused-reflexed, ungulate, or resupinate; upper surface becoming rimose; spores ovoid, truncate at one end, 7–8.5 × 5–6.5 μ. White heartrot of angiosperms, rarely on *Juniperus*, in Sask., Wash., Ore., Idaho, Mont., Wyo., Nev., Utah, Colo., Ariz., and N. Mex. Syn.: *ellisianus* Anders.

213. FOMES PINICOLA (Swartz ex Fries) Cooke. Basidiocarps sessile, effused-reflexed, or resupinate; margin often reddish and resinous; spores ellipsoid, 6.5–7.5 × 3–3.5 μ. Brown rot of gymnosperms, occasionally angiosperms, in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz, and N. Mex. Syn.: *marginatus* (Pers.), *ponderosus* (von Schrenk), *ungulatus* (Schaeff.).

214. FOMES ANNOSUS (Fries) Karst. Basidiocarps usually effused-reflexed, often resupinate; upper surface incrusted, becoming blackish; spores subglobose, 4–5 × 3–4.5 μ. White heartrot and slash rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., Colo., Ariz., and N. Mex. Syn.: *radiciperda* (Hartig).

215. FOMES OFFICINALIS (Vill. ex Fries) Faull. Basidiocarps sessile, ungulate or becoming columnar; upper surface chalky, becoming rimose; taste very bitter; spores ovoid, 3.5–4.5 × 3–3.5 μ. Brown heartrot of gymnosperms in Alaska, B. C., Alta., Wash., Ore., Idaho, Mont., Cal., Nev., Colo., and Ariz. Syn.: *laricis* (Jacq.).

IV. TRAMETES Fries

1a. Context dark to light brown
2a. Spores allantoid; basidiocarps usually resupinate

216. TRAMETES CARBONARIA (Berk. & Curt.) Overh. Pores more or less hexagonal; spores 7–10 × 2.5–4 μ; hyphae with abundant clamp

connections. Brown cubical rot of charred gymnosperm wood in B. C., Wash., Ore., Idaho, Mont., Cal., Ariz., and N. Mex. Syn.: *sequoiae* Copel.

2b. Spores cylindrical, straight; basidiocarps usually sessile or effused-reflexed
3a. Pileus glabrous or tomentose

217. TRAMETES ODORATA (Wulf. ex Fries) Fries. Context tissue dark yellowish-brown or reddish-brown; spores 10–15 × 3–4 μ. Brown cubical rot of gymnosperms, occasionally angiosperms, in Alaska, Yukon Terr., N.W. Terr., B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., and Ariz. Syn.: *americana* Overh.

218. TRAMETES MALICOLA Berk. & Curt. Upper surface and context tissue light brown; context homogeneous; spores 7–11 × 2.5–3.5 μ. Brown rot of angiosperms in B. C., Alta., Wash., Mont., and Wyo.

219. TRAMETES MOLLIS (Sommerf.) Fries. Upper surface becoming blackish; context tissue light brown, with one or more thin black layers; spores 7–10 × 3–3.5 μ. White rot of angiosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Wyo., Cal., and Colo.

3b. Pileus coarsely hispid or hirsute

220. TRAMETES HISPIDA Bagl. Spores 10–15 × 4–5 μ; context thick, duplex, with soft, spongy upper layer. White rot of angiosperms, rarely gymnosperms, in Alaska, Yukon Terr., B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *stuppea* Berk.

221. TRAMETES TROGII Berk. Spores 8–10 × 2.5–3 μ; context thin, not duplex. White rot of angiosperms in Alaska, Idaho, Cal., Colo., and N. Mex.

1b. Context white to ivory or pale buff
4a. Spores echinulate or with pitted exospore

222. TRAMETES COLLICULOSA (Pers.) Lund. & Nannf. Spores cylindric-ellipsoid, appearing minutely echinulate because of pitted exospore, 12–17 × 5–7 μ; pores 2–3 per mm; basidiocarps resupinate. White rot of *Quercus* in Ariz.

223. TRAMETES ODORA (Sommerf.) Fries. Spores ovoid to subglobose, 5–6 × 3–4.5 μ, minutely echinulate; pores 4–5 per mm; basidiocarps sessile or effused-reflexed. White heartrot of living *Salix* in B. C. and Sask.

4b. Spores smooth
5a. Pores small, usually 2–5 per mm

224. TRAMETES SUAVEOLENS L. ex Fries. Basidiocarps usually sessile; context up to 2 cm thick; spores fusiform, 9–11 × 3–3.5 μ; with

fragrant anise odor. White heartrot and slash rot of *Populus* and *Salix* in Alaska, B. C., Alta., Idaho, Mont., Wyo., and Utah.

225. TRAMETES SERIALIS Fries. Basidiocarps usually resupinate; context up to 0.5 cm thick; spores cylindrical, 5–9 × 2–3 μ; without anise odor. Brown rot of gymnosperms, occasionally angiosperms, in Alaska, Yukon Terr., N.W. Terr., B. C., Alta., Wash., Ore., Idaho, Mont., Wyo., Cal., Colo., Ariz., and N. Mex. Syn.: *callosa* (Fries) of many authors.

5b. Pores large, often over 1 mm in diam, rarely more than 2 per mm
6a. Spores 7–10 μ long

226. TRAMETES VARIIFORMIS Peck. Basidiocarps usually reflexed or sessile; upper surface reddish-brown; pores 1–2 per mm. Brown rot of gymnosperms in Alaska, Yukon Terr., B. C., Alta., Wash., Ore., Idaho, Mont., and Colo.

227. TRAMETES ALASKANA Baxt. Basidiocarps resupinate; pores often up to 2 mm in diam. Brown rot of *Picea* and *Tsuga* in Alaska and Wash.

6b. Spores 10–17 μ long
7a. Hyphae slender, 1.5–2.5 μ in diameter

228. TRAMETES CAMPESTRIS Quél. Spores 12–16 × 4–5 μ. White rot of angiosperms in Idaho and Ariz.

7b. Hyphae 2–5 μ in diameter

229. TRAMETES HETEROMORPHA (Fries) Bres. Spores 12–15 μ long; basidiocarps usually effused-reflexed or resupinate, often extensive. Brown rot of gymnosperms and angiosperms in Alaska, Yukon Terr., B. C., Alta., Wash., Ore., Idaho, Mont., Cal., Colo., and Ariz.

230. TRAMETES SEPIUM Berk. Spores 9–12 μ long; basidiocarps sessile, small. Brown rot of angiosperms, rarely gymnosperms, in B. C., Wash., Ore., Mont., Cal., Ariz., and N. Mex.

V. DAEDALEA Fries

1a. Context tissue dark brown

231. DAEDALEA FARINACEA (Fries) Overh. Pore surface greenish; spores cylindrical, often curved, 5–8 × 2–3 μ. White rot of angiosperms in Wash.

232. DAEDALEA BERKELEYI Sacc. Pore surface brownish, often becoming lamellate; spores cylindrical, 7–8 × 2.5–3 μ. On gymnosperms in Ariz.

1b. Context tissue whitish to pale brown
2a. Pores very large, usually over 1 mm in diameter

233. DAEDALEA JUNIPERINA Murr. Basidiocarps generally broadly effused and narrowly reflexed, or resupinate, becoming lamellate; spores cylindrical, 5.5–7 × 2.5–3 μ. Heartrot of *Juniperus* in Ore., Colo., and Ariz.

234. DAEDALEA QUERCINA L. ex Fries. Basidiocarps usually sessile, applanate, becoming lamellate; spores cylindrical, 5–6 × 2–3 μ. White rot of *Quercus*, reported from Ore. and Cal.

235. DAEDALEA CONFRAGOSA Bolt. ex Fries. Basidiocarps sessile, applanate, often becoming lamellate; spores cylindrical, 7–9 × 2–2.5 μ; branched paraphyses in hymenium. White rot of angiosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, and Mont.

2b. Pores smaller, usually 2–4 per mm

236. DAEDALEA UNICOLOR Bull. ex Fries. Upper surface grayish, often hirsute; context with thin, black layers; spores ellipsoid, 5–6.5 × 3–3.5 μ. White rot of angiosperms in Alaska, Yukon Terr., B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., and Colo.

VI. GANODERMA Karst. emend. Pat.

1a. Basidiocarps perennial; context dark purplish-brown to reddish-brown; upper surface usually dull

237. GANODERMA APPLANATUM (Pers. ex Wallr.) Pat. Crust on upper surface hard, not easily broken; tubes layered, separated by a layer of context tissue; spores 7–9 × 4–7 μ. White heartrot and slash rot of angiosperms (especially *Populus*) and gymnosperms in Alaska, B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *megaloma* (Lév.).

238. GANODERMA LOBATUM (Schw.) Atk. Crust on upper surface thin, easily broken; tubes not layered, new pilei developing below the older ones each year; spores 8.5–10 × 5.5–7.5 μ. White rot of angiosperms in Utah and Ariz.

239. **Ganoderma annularis** (Fries) Gilbertson, comb. nov. (*Polyporus annularis* Fries, Nov. Symb. Mycol. p. 52, 1851). Context restricted to hard surface crust; tubes not distinctly layered; spores 10–12 × 6–8 μ. On angiosperms in Cal. Syn.: *tornata* Pers.

240. **Ganoderma brownii** (Murr.) Gilbertson, comb. nov. (*Elfvingia brownii* Murr., Western Polypores p. 29, 1915). Crust on upper surface hard, not easily broken; thick context present; pore surface often pale yellow; spores 9–12 × 7–9 μ. On angiosperms in Cal.

1b. Basidiocarps annual; context pale brownish to ivory; upper surface usually appearing varnished

241. GANODERMA LUCIDUM (Leys. ex Fries) Karst. Context up to 1 cm thick; spores 10–12 × 6–7 μ. White rot of angiosperms in Wash., Ore., Idaho, Mont., and Cal.

242. GANODERMA OREGONENSE Murr. Context up to 5 cm thick; spores 10–16 × 7–9 μ. White rot of gymnosperms in Alaska, B. C., Wash., Ore., Idaho, Mont., Cal., and N. Mex. Syn.: *sequoiae* Murr.

VII. LENZITES Fries

1a. Context tissue white to cream

243. LENZITES BETULINA (L. ex Fries) Fries. Spores cylindrical, 4–7 × 1.5–3 μ; upper surface zonate, hirsute; cystidia present. White rot of angiosperms in B. C., Alta., Wash., Ore., Idaho, Mont., and Cal.

1b. Context tissue pale brown to dark brown

244. LENZITES SAEPIARIA (Wulf. ex Fries) Fries. Upper surface usually zonate, often with bright yellowish- or reddish-brown zones; context bright yellowish- to reddish-brown; spores cylindrical, 8–10 × 3–3.5 μ. Brown rot of gymnosperms, occasionally angiosperms, in Alaska, Yukon Terr., B. C., Alta., Sask., Wash., Ore., Idaho, Mont., Wyo., Cal., Utah, Colo., Ariz., and N. Mex. Syn.: *abietinella* (Murr.), *hirsutum* (Schaeff. ex Murr.).

245. LENZITES TRABEA Pers. ex Fries. Upper surface dull brown, faintly zonate or azonate; context pale brown; hymenophore often remaining poroid; spores cylindrical, 7.5–9 × 3–3.5 μ. Brown rot of angiosperms, occasionally gymnosperms, in Wash., Ore., Idaho, Mont., Cal., and Colo.

246. LENZITES STRIATA (Swartz ex Fries) Fries. Basidiocarps thin; upper surface dull rusty brown, often becoming grayish; spores cylindrical to ellipsoid, 6–8 × 2–4 μ; cystidia abundant. On gymnosperms in Ariz.

VIII. FAVOLUS Beauv. emend. Fries

247. FAVOLUS ALVEOLARIS (DC. ex Fries) Quél. Upper surface reddish-yellow, scaly, becoming ivory or almost white; spores 9–11 × 3–3.5 μ. White rot of angiosperms in Alaska, B. C., Idaho, Mont., and Colo. Syn.: *canadensis* Klotzsch.

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MORPHOLOGICAL STUDIES IN THE CHAETOMIACEAE. I[1]

W. C. WHITESIDE

(WITH 33 FIGURES)

The Chaetomiaceae is generally defined to include those phaeosporous Ascomycetes having evanescent asci that are contained in a perithecium adorned by prominent hairs or setae. Usually regarded as comprising the family are four genera: *Chaetomium*, *Chaetomidium*, *Ascotricha*, and *Lophotrichus*. Only for a few species of *Chaetomium* has the developmental morphology been investigated, despite current emphasis on the importance of morphological studies in the classification of Ascomycetes. The purpose of this study is to compare the pattern of ascocarp development in selected species of each of the four genera. The first paper will treat the genus *Chaetomium*, the second, *Chaetomidium* and *Ascotricha*, and the third, *Lophotrichus*.

CHAETOMIUM

The most recent monograph of the genus *Chaetomium* Kunze (Skolko and Groves, **1948**, **1953**) recognizes over fifty species. Additional species of *Chaetomium* have since been described by Ames (**1950**) and by Omvik (**1955**), and several other species attributed to Sergejeva are listed in the January, 1959, supplement to the catalogue of the Commonwealth Mycological Institute. Skolko and Groves, as Chivers (**1915**) did previously, restrict the genus *Chaetomium* to those species with perithecia that are superficial and ostiolate. The perithecial hairs, particularly the terminal ones, show considerable variation among species. These hairs may be branched or unbranched and either straight or variously contorted or coiled. The ascus is usually distinctly clavate in form, although in a few species it is cylindrical with monostichous ascospore arrangement.

[1] This paper is based upon a portion of a Ph.D. dissertation submitted to the Graduate School of Florida State University in 1959. The author wishes to express his gratitude to Prof. Leland Shanor for directing the research and for critically reading the manuscript and to Prof. A. W. Ziegler for numerous suggestions offered during the course of the investigation.

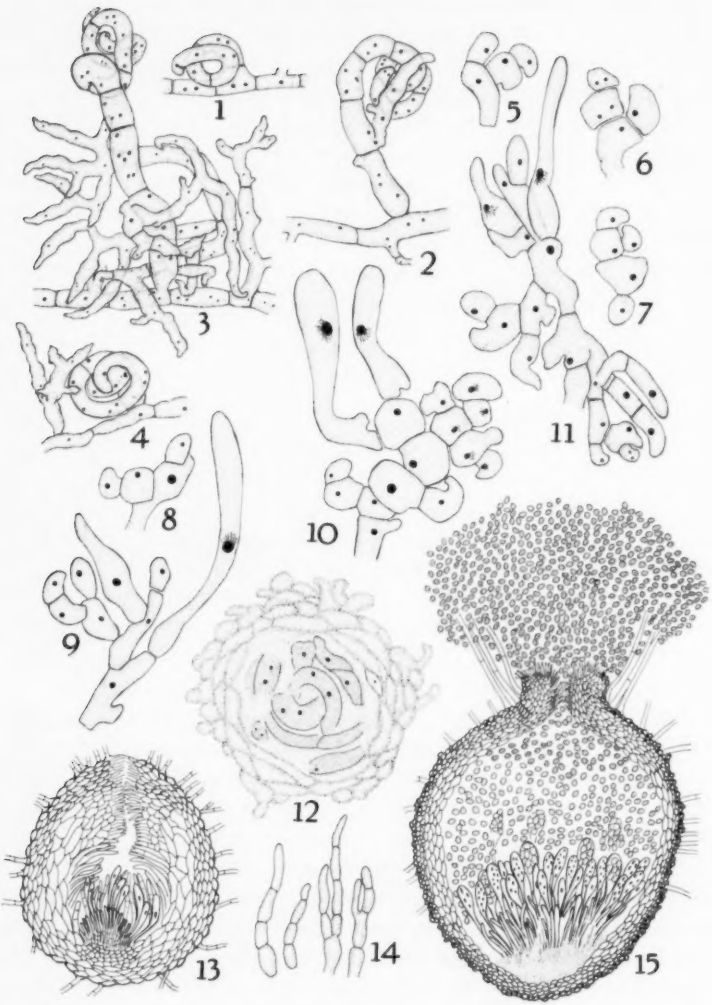
Available in the literature are reports of almost a dozen morphological studies concerned with the genus *Chaetomium*. In view of the variation occurring in this large genus, surprisingly few of the species have been subjected to developmental observations. A large number of the studies have been devoted to *Chaetomium globosum* Kunze, a species commonly referred to under the synonym *C. Kunzeanum* Zopf by many of these investigators. Since the literature pertaining to ascocarp initiation in *Chaetomium* has recently been reviewed by Whiteside (**1957**) in a paper reporting two patterns of ascogonial development in this genus, the *Chaetomium globosum* pattern and the *Chaetomium brasiliense* pattern, these various studies will not be enumerated.

MATERIALS AND METHODS

Cultures of *Chaetomium globosum* Kunze and *C. brasiliense* Batista & Pontual were derived from those supplied to the Mycological Culture Collection of the University of Illinois by Dr. L. M. Ames, the latter species under the name *C. velutinum* Ames. Culture media employed were the basal synthetic medium of Lilly and Barnett (**1951**), potato dextrose agar, and particles of sterilized oatmeal covered by 1½% agar.

The morphological observations consisted of three different phases: the study of ascocarp initiation, of ascocarp development and structure, and of the ascogenous hyphae. Each involved somewhat different techniques.

With favorable media and temperature, ascogonia of these two species appear two days after inoculation. For gross observation of the ascogonia, small portions of mycelium were mounted in a drop of an aqueous solution of phloxine. The cytological study of the ascocarp initials involved a whole-mount method. The fungus was grown on sterilized pieces of dialyzable membrane placed over the culture medium. At the proper stage of development these strips of membrane, along with the adhering fungus growth, were peeled from the agar and dealt with as whole-mount material. The killing and fixing agent employed was either the modification of Navashin fluid by Raper (**1936**) or by Randolph (Johansen, **1940**), the fixation time being approximately 18 hours. The material was then dehydrated according to the following schedule: 10% ethyl alcohol for 15 minutes; 20, 30, and 40% ethyl alcohol for 30 minutes each; 50, 60, 70, and 80% ethyl alcohol for one hour each; 95% ethyl alcohol overnight; and absolute ethyl alcohol for one hour. Hydration was accomplished by passing down through the alcohols at 15 minute intervals. Mordanting was carried out in 4% iron alum for a period



FIGS. 1–15. *Chaetomium globosum*. 1–4. Ascogonia. × 1000. 5–11. Ascogenous hyphae. The elongate cells in FIGS. 9–11 are young asci. Binucleate ascogenous cells are illustrated in FIGS. 6 and 11. × 1000. 12. Section of very young perithecium showing the ascogonial coil surrounded by sterile cells. × 1000. 13. Section of ascocarp at the time asci are beginning to form. Note the open space above the developing asci. × 170. 14. Hymenial paraphyses. × 400. 15. Section of mature perithecium. × 170.

of two to three hours, after which the material was washed for 15 minutes and then placed in 0.5% aqueous solution of hematoxylin for two hours. Following 15 minutes in water, destaining was accomplished in 2% iron alum for 4½ to 5 minutes. The material was then washed in water for 30 minutes and passed back through the alcohols at 10 minute intervals. Xylol was used in clearing and piccolyte for mounting.

Observation of ascocarp development and structure was mostly from sectioned material. The killing and fixing agents used were the previously mentioned modifications of Navashin fluid, and structures were differentiated by the Gram's stain or by Heidenhain's hematoxylin stain. With the ascogenous hyphae, excellent results were obtained by the use of the propiono-carmine smear method.

OBSERVATIONS

CHAETOMIUM GLOBOSUM. The cells of the vegetative mycelium are commonly multinucleate, with the number of nuclei observed per cell ranging from one to six or more. Often these nuclei occur in pairs, which are probably the result of rapid mitotic division. With both hematoxylin and gentian violet, the nucleus stained as a single condensed granule that was frequently observed to be surrounded by a clear zone. The ascocarp of *Chaetomium globosum* is initiated by a special hyphal branch designated as the ascogonium. The apical region of the ascogonium forms an irregular coil which is either sessile (FIGS. 1, 4) or which occurs at the apex of a stalk consisting of several cells (FIGS. 2, 3). From the main hypha (FIGS. 3, 4) or from the stalk of the ascogonium (FIGS. 2, 3) arise outgrowths that invest the coil. The nuclear condition of the ascogonium is similar to that of the vegetative hyphae. Most of the cells of the ascogonium contain two, three, or four nuclei, but those with a single nucleus or with a greater number than four were not uncommonly seen. The tip cell contains a variable number, usually four to eight (FIGS. 1, 4). As in the cells of the vegetative hyphae, some of the nuclei in the ascogonium are closely approximated as pairs. The nuclei of the hyphae which envelop the ascogonium were observed to be smaller than those of the ascogonium and more widely separated from other nuclei (FIGS. 3, 4).

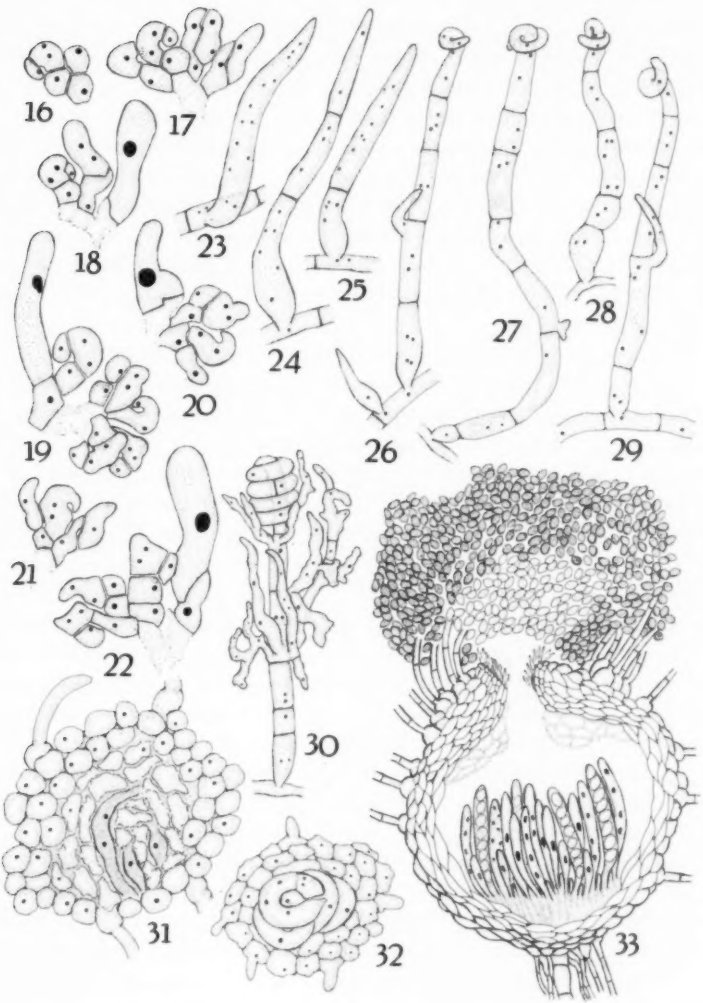
In sectioned material of young perithecia, fragments of the ascogonial coil are recognizable by more intensely stained, generally larger nuclei (FIG. 12). Crosswalls within the coil sometimes can be observed at this stage, and the cells of the ascogonium are apparently still multinucleate. At the time the structure of the mature centrum begins to

take form (FIG. 13), there can be differentiated a peridial zone made up of about six layers of compacted cells, the outermost cells of this layer eventually becoming pigmented. The next region, about one-half dozen cells across, consists of tangentially-elongated, thin-walled cells that are considerably larger than the peridial cells. The nuclei of these sterile cells usually fail to stain. When these nuclei do stain, they are very unlike the readily-stained nuclei of the ascogenous cells, tending to be larger, more granular, and absorbing considerably less stain. Originating from the inner surface of this layer of sterile cells are paraphysis-like, septate filaments directed centripetally and slightly upward. Oltmanns (**1887**) called these filaments periphyses, while Luttrell (**1951**) spoke of them as paraphyses. The ostiole is lined by abundant periphyses.

The young asci originate as a basal tuft from a conical mass of ascogenous hyphae. It is believed that the ascogenous hyphae originate from the ascogonial coil. In association with the asci occur septate, occasionally branched paraphyses (FIGS. 13, 14). The ephemeral nature of these paraphyses explains the several reports in the literature denying the presence of these structures in *Chaetomium globosum*.

Developing above the young asci is a cavity, which probably results largely from differential growth of the filaments composing the ascocarp wall, supplemented perhaps by the action of the paraphyses. As the perithecium ages, the paraphyses, both those originating from the hymenium and those lining the walls of the cavity, disappear. The uniformly thin-walled ascus is clavate with an irregular arrangement of the eight spores. Before the ascospores are fully pigmented, the asci deliquesce. The ascospores mature within the cavity of the perithecium and are eventually extruded though the ostiole and accumulate in a mass among the terminal perithecial hairs (FIG. 15). The spores possess a terminal germ pore.

In sectioned material, the cells of the ascogenous hyphae appear to be uninucleate. Carmine smear preparations of the ascogenous hyphae confirm this observation (FIGS. 5–11). However, a few scattered cells, particularly terminal ones, were found to be binucleate (FIGS. 6, 11). Only once were two binucleate cells in succession noted (FIG. 6). Frequently the nuclei of the binucleate cells appeared smaller than those in uninucleate cells, suggesting that the binucleate condition had resulted from a recent division. Crozier formation was not observed. Before meiotic division, the fusion nucleus enlarges greatly. The nuclei of the ascogenous cells and young ascus appear as compact, intensely-staining spheres. In this type of ascomycete nucleus, it is usually regarded that the chromatin becomes contracted about the nucleolus. In some prepara-



FIGS. 16–33. *Chaetomium brasiliense*. 16–22. Ascogenous hyphae showing abundant crozier formation. Young asci are shown in FIGS. 18, 19, 20, and 22. × 1000. 23–25. Mycelial setae. × 1000. 26–30. Ascogonia. × 1000. 31, 32. Sections of very young perithecia showing portions of the ascogonial coil. × 1000. 33. Section of mature perithecium. Note lack of free ascospores in perithecial cavity. × 400.

tions, however, chromatin material was observed as distinct from the nucleolus (FIGS. 9–11).

CHAETOMIUM BRASILIENSE. In *Chaetomium brasiliense* the ascocarp originates from a specialized hyphal branch, the ascogonium (FIGS. 26–30). The ascogonium consists of several stalk cells, and generally the apical region of the ascogonium grows down around the stalk to form a symmetrical coil (FIG. 30). Ascogonial coils with as many as eight spirals have been observed. Hyphal branches originating from the stalk cells grow upward around the coil and form the perithecial wall (FIGS. 26, 29, 30). Since the stalk of the ascogonium usually attains a considerable length, the mature perithecium is generally elevated above the culture medium.

Nuclei in this species were observed to have the same staining capacity as those in *Chaetomium globosum*. The nuclear condition of the vegetative hyphae and of the ascogonia is similar to that observed in *C. globosum*. The cells of the vegetative hyphae are usually plurinucleate, and in these cells paired nuclei and nuclei which appeared to be dividing were observed many times. The number of nuclei in the stalk cells of the ascogonium range from one to five or more. Two, three, or four nuclei are most common, and here also the nuclei are often paired, suggesting recent division. As the development of the apical coil progresses, the nuclei in the stalk cells stain less intensely, particularly those in the more basal cells. Because of the difficulty of determining septations in the ascogonial coil of this species, cytological preparations of this stage were not as satisfactory as those obtained with *C. globosum*. It is believed, however, that the segments in the coil are plurinucleate. The usual number of nuclei per spiral was one or two, generally showing no spatial approximation into pairs (FIG. 30).

This species is characterized by the abundant production of setae on the surface mycelium (FIGS. 23–25). These setae develop before the ascogonia and closely resemble the lateral hairs of the perithecium. The young hairs are at first one-celled and multinucleate (FIG. 23) but soon become divided into segments having several nuclei (FIGS. 24, 25).

In sectioned material of young ascocarps, the somewhat larger size of nuclei in the ascogonial coil helps to differentiate the cells of this structure from those of the wall (FIGS. 31, 32). The centrum structure is similar to that of *C. globosum*. The ascocarp wall is composed of two layers of tangentially elongated cells—an outer zone of relatively small cells that develop dark pigmentation and an inner zone of much larger cells with very thin cytoplasm. In FIGURE 33, these inner cells have already been destroyed, the same fate having occurred to the paraphyses

which originate from the lateral walls of the perithecial cavity. Hymenial paraphyses were not demonstrated in either sectioned material or squash preparations. As in *C. globosum* an open space forms above the young asci. The cylindrical ascus possesses a definite stipe and the ascospores have a linear arrangement. The ascospores are released from the ascus, presumably by deliquescence of the ascus wall, before pigmentation is complete. Accumulation of spores in the perithecial cavity does not occur, and instead the extruded ascospores mature outside the ostiole among the perithecial hairs (FIG. 33). Just as in *C. globosum*, the ostiole is lined by periphyses and germination of the ascospores is by a terminal germ pore.

The height of the zone of ascogenous hyphae is less than in *C. globosum*. All asci appear to develop from the penultimate cell of a crozier, for squash preparations of the ascogenous hyphae show abundant crozier formation (FIGS. 16–22). Frequently the penultimate cell does not mature into an ascus but rather develops into another crozier. Conjugate division in the young croziers was sometimes noted. As in *C. globosum*, the fusion nucleus is very much larger than the nuclei of the ascogenous hyphae.

DISCUSSION

The extensive treatment by Greis (**1941**) of *Chaetomium globosum* and *C. bostrychodes* Zopf is widely known and is cited in the works of Gäumann (**1952**), Olive (**1953**), and Bessey (**1950**) as representing the cytological condition for these species. He described functional antheridia in both species, a condition denied by Vallory (**1911**) in his cytological study of *C. globosum* and by Dangeard (**1907**) in *Chaetomium spirale* Zopf. Greis stated that one or more antheridial nuclei pass into the multinucleate, one-celled ascogonium. After pairing of the antheridial nuclei with those of the ascogonium, conjugate division was reported as occurring, along with crosswall formation. For *C. globosum* he described a condition apparently unique for Ascomycetes, since he stated that the fertilized ascogonium may either develop directly into a perithecium or it may send out binucleate primary ascogenous hyphae, at the ends of which perithecia may develop. The development of as many as eleven separate perithecia from one fertilized ascogonium was reported by this author. In both species the cells of the ascogenous hyphae were described as binucleate and crozier formation as lacking. Greis apparently used only sectioned material, stained with hematoxylin, for no mention is made of carmine smear preparations.

In a recent study, van der Weyen (**1954**) made use of the carmine

smear technique in a cytological study of *C. globosum* and failed to confirm many of the observations of Greis. The description by Greis of the proliferation of the ascogonium to produce a number of perithecia rather than a single one, the condition apparently normal for all Ascomycetes, could not be confirmed. Although van der Weyen was unable to obtain satisfactory cytological preparations of the ascogonium, he reported a prolonged dicaryophase is apparently lacking, since he described the cells of the ascogenous hyphae as mostly uninucleate. The presence of crozier formation was claimed for this species.

Most of the findings in this present study are in accord with those of van der Weyen and generally fail to corroborate those of Greis. Since van der Weyen did not succeed in adequately staining ascogonia of *C. globosum*, he was unable to deal authoritatively with this phase of the cytology. When ascogonia of this species were stained with hematoxylin, I found the cells to lack a uniform nuclear content, with the number of nuclei per cell ranging from one to four or more. Some of these nuclei are approximated closely in pairs, but others occur widely separated. The nuclear condition of the cells of the vegetative hyphae appeared to be no different. Since paired nuclei are abundant in both the vegetative hyphae and the ascogonia, it seems very possible that this condition results from rapid mitotic division rather than from conjugate division.

The report by van der Weyen of crozier development in *C. globosum* requires attention. Previously, this species was described as lacking croziers. Van der Weyen's figures illustrating what he considered to be crozier development in *C. globosum* are not convincing, and from the text it can be inferred that croziers were not common. In this present study, however, no croziers were observed. There was nothing comparable to the abundant development of distinct croziers in *C. brasiliense*. The general sparsity of binucleate cells in the ascogenous hyphae of *C. globosum*, and these having positions hardly suggesting the penultimate cell of a crozier make it seem extremely doubtful that croziers are of frequent occurrence, if they occur at all, in *C. globosum*.

The predominantly uninucleate condition of the ascogenous hyphae of *C. globosum* presents another consideration of some significance, namely, whether the asci have their origin from the uninucleate cells or from the infrequent binucleate ones. Van der Weyen treated the binucleate cells as representing young asci. Emmons (**1932**) reported ascogenous hyphae having similar nuclear characteristics for *Thielavia Sepedonium* Emmons. In this species, he believed that the asci develop from the uninucleate cells, while the occasional binucleate ones, largely terminal

are the result of vegetative proliferation of the ascogenous hyphae. It is interesting to note that the variation between the ascogenous hyphae of *C. globosum* and *C. brasiliense* parallels that given by Emmons for two species of *Thielavia*. He described *T. Sepedonium* as producing ascogenous hyphae predominantly uninucleate and devoid of croziers, indeed suggestive of *C. globosum*. For *Thielavia terricola* Gilman & Abbott he reported ascus formation by typical croziers, a condition occurring in *Chaetomium brasiliense*.

In addition to differences in the ascogenous hyphae, the comparative study of *Chaetomium globosum* and *C. brasiliense* has indicated for this genus variation in several other morphological features. In *C. globosum* the ascogonium is coiled irregularly, hymenial paraphyses are present, and mycelial setae are lacking. The perithecia are relatively large and possess abundant rhizoids. In *C. brasiliense*, on the other hand, the ascogonium coils symmetrically at the apex of a long ascogonial stalk, hymenial paraphyses are lacking, and mycelial setae occur in abundance. The perithecia are about half the size of those of *C. globosum* and lack rhizoids, this latter condition probably related to the elongated ascogonial stalk. A limited amount of comparative study with other species of *Chaetomium* suggested that certain of these characteristics may be useful for recognizing groups of species within the large genus *Chaetomium*. On the basis of existing evidence, these groupings do not seem to be correlated closely with the form of the ascus and of the terminal hairs.

In the classic treatment of Lindau (**1897**), the Chaetomiaceae was a family in the suborder Sphaeriales of the order Pyrenomycetineae. The presence of an ostiole, the arrangement of the asci, and the dark membranous ascocarp walls were characters accepted by most subsequent mycologists to justify this position. Nannfeldt (**1932**), however, emphasized the deliquescent nature of the ascus and transferred the family to the Plectascales. Gäumann (**1952**) accepted this interpretation, except that the family Chaetomiaceae was not recognized and genera usually placed in this family were placed in the Ophiostomataceae. Luttrell (**1951**) treated the Chaetomiaceae in his order Xylariales, an order similar in concept to the Sphaeriales of other authors. Von Arx and Müller (**1954**) deal with the genera of the Chaetomiaceae in the family Melanosporaceae of the order Sphaeriales, and Munk (**1957**) adhered to this delimitation of the family Melanosporaceae.

On the basis of Oltmanns' (**1887**) morphological work with *Chaetomium globosum*, Luttrell (**1951**) considered *Chaetomium* as having a development and centrum of the *Xylaria* type. The description of perithecial structure of *C. globosum* as recorded by Oltmanns is essentially

that given in this report; however, Oltmanns failed to detect hymenial paraphyses. *Chaetomium brasiliense* has the same centrum structure as *C. globosum* with the exception that hymenial paraphyses are lacking. Except for the evanescent nature of the ascus, there is a close resemblance of the centrum structure of *Chaetomium* to that of the family Xylariaceae, which both Nannfeldt (**1932**) and Miller (**1949**) considered to exemplify most fully the concept of the Sphaeriales and upon which Luttrell (**1951**) based his order Xylariales. The genus *Chaetomium*, then, has the ascocarp structure of an ascohymenial pyrenomycete but an ascus, although somewhat elongated, very similar to the evanescent type found in plectomycete genera such as *Thielavia*. It is equally possible, of course, that a particular centrum structure or a certain type of ascus could have evolved independently more than once. It is known, for example, that a deliquescent ascus occurs in several taxonomic groups otherwise widely separated. The morphology of the ascus and of the ascocarp of genera such as *Chaetomium* and *Thielavia* is very different from that of a fungus such as *Periosporium funiculatum* Preuss. Yet, all are characterized by a deliquescent ascus. For practical purposes, therefore, it seems desirable to stress centrum structure in assigning an ordinal position to *Chaetomium*, thus placing the genus within the traditional concept of the order Sphaeriales.

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THE DISTRIBUTION OF EMMONSIA CRESCENS IN EUROPE

WILLIAM L. JELLISON [1] AND J. WILLIAM VINSON

In the spring of 1959 the writers spent 3½ months in Europe collecting and examining small mammals for parasites and disease agents. The primary purpose was to secure further information on *Emmonsia crescens* Emmons & Jellison, a fungal pulmonary parasite, which has been found widely distributed in North America and elsewhere but which had been reported in Europe only from England (**10**) and Sweden (**4**). This study was successful in increasing the known host and geographical range of the agent. Some of the records have already been published separately for the countries of Norway, Sweden, Finland and France; however, it appears desirable to prepare a more comprehensive report from these data. Specimens have been received from several colleagues in Europe since the 1959 visit and information on these will be included.

COLLECTION AREAS

Facilities at the County Veterinary Laboratory at Hamar, Norway, were utilized for our first work and there we were assisted in field studies by Dr. Erik Holager, Director of the Laboratory. We trapped small animals within a 10-mile radius of Hamar and others were obtained by paying a bounty to farmers and school boys. Some specimens were from Lillihammer, which is 40 miles north of Hamar, and a few were from various places in the southern half of Norway. When we were there in March and April it was not practical to trap small rodents in northern Norway. However, Mr. Jörgen Pedersen, Zoologist at Vollebekk, Norway, later provided numerous lung samples, most of which were from rodents in northern Norway.

In Sweden we used laboratory space at the State Veterinary Institute, Stockholm, and most of the small animals which we examined while fresh were trapped in the small area of forest on the Institute grounds. Some animals preserved in formalin or alcohol at the Swedish National Museum were also studied.

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Mr. Matti Helminen of the Finnish Game Foundation at Helsinki provided us with laboratory facilities in Finland and obtained many carcasses from trappers and zoology students in southern Finland for autopsy. Mr. Tarna of the Finnish Game Foundation has continued the study which we initiated on *Emmonsia* and has supplied us recently with several interesting records of this organism. Preserved animals in collections of the National Museum at Helsinki were also examined.

Studies in France were very limited and consisted of examination of: preserved museum specimens at the Natural History Museum; a series of lung specimens collected by Mr. Jacques Giban, rodent control specialist, from several areas in France, June 1959; and a few animals collected near Paris by zoology students in June 1959.

A few days were spent at Bejeljina, Jugoslavia, but only a small number of animals were obtained for study. Later in 1959, Dr. Jacob Gaon, Faculty of Medicine, Sarajevo, arranged for the collection and shipment of a small series of rodents from Bejeljina.

No animals were examined in Germany but a veterinary parasitologist, Dr. Erika Pezenburg at the Institute for Parasitology, Berlin-Dahlem, was informed of our interest and has reported the finding of *Emmonsia* in Germany (**11**).

Published records of McDiarmid and Austwick (**10**) and Tevis (**12**) indicate that *Emmonsia* is a fairly common parasite of small mammals in parts of England. Several scientists were visited in England but no significant material was examined in that country.

RESULTS

Norway: The animals examined in Norway are listed in TABLE I.

Representative specimens of most of these species were prepared as study skins or preserved in alcohol and have been identified by Miss Barbara Lawrence of the Museum of Comparative Zoology (MCZ), Harvard University. The following species were from Norway: *Apodemus flavicollis flavicollis, Apodemus sylvaticus sylvaticus, Arvicola terrestris terrestris, Clethrionomys glareolus suecicus, Lemmus lemmus, Microtus agrestis agrestis, Mus musculus, Rattus norvegicus, Sciurus vulgaris,* and *Sorex araneus araneus.*

The second animal examined, a specimen of water vole or water rat, *Arvicola terrestris terrestris* L., was heavily infected with *Emmonsia.* This vole was collected March 18, 1959, by a school boy, Tråndt Sannerud of Hamar, near the door of his home. He thought the animal was acting

TABLE I

ANIMALS EXAMINED FOR EMMONSIA CRESCENS IN NORWAY, MARCH–APRIL 1959

Hosts	Number examined	Number infected
Mus musculus, house mouse	239	0
Apodemus spp., wood mice	102	0
Sus sp., domestic pig	60	0
Sorex sp., shrew	40	0
Rattus norvegicus, rat	27	0
Clethrionomys sp., red-backed mouse	22	0
Mustela vison, mink	22	0
Vulpes sp., fox	14	0
Microtus sp., vole	10	4
Felis catus, domestic cat	9	0
Lepus sp., rabbit	6	0
Sciurus sp., squirrel	4	0
Mustela sp., weasel	4	0
Arvicola terrestris, water vole	1	1
Lemmus sp., lemming	1	0
Meles meles, badger	1	0
Total	562	5

abnormally and was possibly ill. Many cultures, the first for continental Europe, were made from this specimen, and tissues were preserved for sections and for other microscopic preparations. A culture from this animal has been selected as the type for a new species, *Emmonsia crescens*, described by Emmons and Jellison (**3**). Ten tissue spherules, adiaspores, from this host measured 440 μ to 481 μ in diameter with an average of 460 μ. This was the only specimen of *A. t. terrestris* seen or collected in Norway in the course of our studies although the species is supposed to be fairly common and at times abundant in favorable habitats which are marshy areas.

Four other rodents from the vicinity of Hamar were also infected with *E. crescens*. These were nos. 143, 145 and 153, *Microtus agrestis agrestis* and no. 167, *Clethrionomys glareolus suecicus*. (Specimen No. 167 was listed as an immature *Microtus* ♀ by Jellison et al. (**7**).) These records of mammals infected with *E. crescens* have already been published (**7**).

TABLE II

MAMMAL SPECIMENS RECEIVED FROM NORWAY 1959–1961

Source of specimens	Number	Number infected
Zoological Museum, Bergen	265	3
Zoological Museum, Oslo	142	3
Zoological Museum, Trondheim	93	3
Collected by Mr. Pedersen	177	3
Total	677	12

At a later time, Mr. Jörgen Pedersen, Zoologist, Vollebekk, Norway, made a rather extensive survey of small rodents in the northern regions and elsewhere in Norway and supplied many lung samples for examination. He also secured lungs from preserved museum specimens at several institutions in Norway for examination. Data on these collections are given in TABLE II.

Information on the infected animals was as follows:

Clethrionomys glareolus (6); Sogn og Fjordene County, 5 July 1914 and 13 July 1914, Akershus County, May 1898, Trondheim, 13 March 1951, 20 March 1951, 17 February 1951.

Clethrionomys rufocanus (2); Hordaland County, 26 Nov. 1894, Fenmark County, 30 April 1907.

Arvicola terrestris (1); Akershus County, 14 May 1907.

Apodemus sylvaticus (2); both from Vollebekk, Akersus County, 1959.

Microtus agrestis (1); Plurdalen, 20 km east of Moi Rana, Nordland County, 14 Sept. 1959 (about 27 km south of Arctic Circle).

The great majority of the specimens from museum collections was rodents, but the lungs sent by Mr. Pedersen included those of a few ferrets, and 24 mink, *Mustela vison*, which has been introduced into Europe from America.

Sweden: In the first report of *E. crescens* (= *Haplosporangium*) from Sweden (**4**), one wood mouse, *A. f. flavicollis*, of 31 examined was found to be infected. These animals came from near Gullgrava, Gävleborg County, Sweden. However, the tissues had been preserved in alcohol and culture of the mycotic agent was not possible. This finding stimulated a more extensive search for the fungus in Sweden and elsewhere in Scandinavia in 1959. One hundred fifty-eight animals, which included 115 fresh specimens and 43 museum specimens, were examined (TABLE III). Many of the fresh animals were trapped in the forest at the Veterinary Research Institute grounds and others had been shipped to the Institute for autopsy. The museum specimens were from widely scattered areas in Sweden but many were from the far North. No unusual mammal distribution records were noted in this survey so specific localities are not recorded here.

Some of these specimens have also been identified by Miss Lawrence at MCZ and the following species recognized: *A. f. flavicollis*, *A. f. sylvaticus*, *C. g. succicus*, and *S. a. araneus*.

E. crescens was found in 4 mammals, cultures were established, and the identification of the fungus further confirmed as has been reported by Jellison, Vinson and Borg (**9**).

Data concerning the 4 infected animals are as follows:

Nos. 262 and 274, *A. s. sylvaticus,* trapped on Veterinary Institute grounds, April 1959. Cultures were established from both animals.

No. 340, *Microtus agrestis,* a museum specimen preserved in the Swedish National Museum, collected at Lund, 1845, by M. V. Düben. The lung of this animal contained a single spherule, 414 μ in diameter. This is the earliest known collection record of *Emmonsia.*

TABLE III

ANIMALS EXAMINED FOR ADIASPIROMYCOSIS IN SWEDEN, APRIL 1959

	Fresh specimens	Museum specimens	Total	Number infected
Mus musculus, house mice	35	0	35	0
Apodemus spp., wood mice	29	0	29	2 (Fresh)
Sorex sp., shrews	22	0	22	0
Clethrionomys sp., red-backed mice	4	16	20	0
Lemmus sp., lemming	0	17	17	0
Microtus, voles	6	5	11	1 (Museum)
Mustela vison, mink	7	0	7	0
Lepus sp., hares	5	0	5	0
Rattus norvegicus, rats	3	2	5	0
Shrews, probably water shrews	1	3	4	1 (Museum)
Martes sp., pine marten	1	0	1	0
Vulpes sp., fox	1	0	1	0
Myocastor coypus, nutria (an exotic rodent)	1	0	1	0
Total	115	43	158	4

No. 350, shrew, probably a water shrew, *Neomys fodiens,* 1 of 3 large shrews preserved in one jar at the Swedish National Museum. Collected 1908 at Engelsberg, Province of Vastmanland, west of Stockholm.

We have recently (February 1961) received tissues from an otter, *Lutra lutra,* found dead in the vicinity of Rättvik, Kopparberg County. This animal was autopsied at the Veterinary Research Institute and a heavy infection of *Emmonsia* was noted. Death was attributed to pneumonia, possibly associated with *Emmonsia* infection.

Favus infection in mice. The only mycotic infection other than adiaspiromycosis encountered in the many animals examined from Sweden was favus. House mice, *Mus musculus,* were abundant in stables and animal shelters at the Veterinary Research Institute. Six of 35 mice

examined were infected. Some bore large disfiguring scutula and appeared to be stunted and emaciated by the massive infection. Cultures were established from several animals and have been identified as *Microsporum quinckeanum* Zopf [*Trichophyton quinckeanum* (Zopf) MacLeod & Muende], by Dr. Heiti Paldrok, mycologist, State Bacteriology Laboratory, Stockholm, Sweden.

Favus in mice is a common source of human infection. It has practically world-wide distribution according to Blank (**1**) who has reviewed the literature but apparently it has not been recorded previously for Sweden.

Finland: In Finland, muskrat carcasses were sent to the Game Foundation by commercial trappers after they had removed the pelts. Such carcasses were suitable for examination and culture. A zoology student

TABLE IV

ANIMALS EXAMINED IN FINLAND, MAY 1959

	Fresh specimens	Museum specimens	Total	Number infected
Microtus spp., voles	1	59	60	1 (Museum)
Clethrionomys sp., red-backed mice	0	27	27	0
Ondatra zibethica, muskrats	35	0	35	2 (Fresh)
Arvicola terrestris, water rats	12	7	19	7 (2 Fresh) (5 Museum)
Lemmus lemmus, lemming	0	10	10	0
Lepus sp., hare	1	0	1	0
Total	49	103	152	10

was paid to trap small mammals other than fur bearers in the vicinity of Helsinki and supplied a number of water voles, *A. t. terrestris*. Small rodents preserved in alcohol at the Zoology Museum of the University, Helsinki, were also examined. All of the species examined were indigenous to Finland except the American muskrat, *Ondatra zibethica*, which was introduced into Europe and Asia and is now widespread.

Of the 152 animals autopsied, 10 were found infected with *E. crescens*. Both preserved museum specimens and freshly trapped animals were infected.

Sixty-nine of the specimens of *Microtus*, *Clethrionomys*, and *Lemmus*, which were preserved at the Zoology Museum, came from Kilpisjärvi in the extreme northwestern part of Finland. None of these were found infected.

The animals examined in Finland are listed in TABLE IV.

Collection data and findings for the infected animals are as follows:

No. 360. Mature muskrat, ♀, *O. zibethica,* Silinjarvi Commune, Finland, May 4, 1959; two spherules in portion of lung examined measured 170 μ and 244 μ in diameter.

No. 363. Mature muskrat, *O. zibethica,* Commune of Koijarvi, Finland, April 30, 1959. Very heavy infection throughout the lungs. Cultures established.

No. 366 A and B. Water rats, *A. terrestris,* Korpholm Island, in Sipoo about 25 miles east of Helsinki, Finland, August 27–28, 1954, collected by the late Prof. I. Valikangas. Five rodent specimens preserved in alcohol at the Zoology Museum, Helsinki. Two of these 5 were infected, one with very numerous spherules, one with a few scattered spherules.

No. 369. Water rat ♂, *A. terrestris,* near Helsinki, Finland, May 5, 1959. Moderate infection. Ten spherules dissected out measured 429 μ maximum, 384 μ minimum, and 414 μ average diameter.

No. 371. Vole, large ♂, *Microtus agrestis,* near Helsinki, Finland, April 5, 1959. Only two spherules, 326 μ and 348 μ diameter.

No. 372. Water rat, *A. terrestris,* near Helsinki, Finland, May 6, 1959. Heavily infected. Portion of lung sent to Dr. Anderson, D.V.M., Veterinary Research Institute, Helsinki, for culture and pathologic study.

No. 373. Water rat, *A. terrestris,* near Helsinki, Finland, May 6, 1959. Light infection with spherules. Minimum 296 μ maximum 407 μ, average 353 μ diameter.

No. 375. Water rat, *A. terrestris,* near Helsinki, Finland, May 7, 1959.

No. 377. Water rat, *A. terrestris,* near Helsinki, Finland, May 7, 1959.

Since completion of our studies in Finland, Mr. Tarna of the Finnish Game Research Institute has made some additional observations on *E. crescens* in Finland. We do not have all his results but he has sent to us microscopic sections of lungs from: a muskrat, *O. zibethica,* a vole, *A. terrestris,* and a lemming, *Lemmus* sp. The lemming was taken at Kilpisjärvi, Finland, 69° N. Adiaspores of *E. crescens* are recognizable in each. This is the first and only record of the fungus in any species of lemming that has come to our attention. It adds a new parasite to the few that are known from lemming. It implicates a host with extensive geographic distribution in the arctic and subarctic regions, a host that occurs in enormous numbers at rather regular intervals and

one that is of much biological interest. It is expected that Mr. Tarna will publish the results of his more extensive survey for *Emmonsia* in Finland. Most of these records from Finland have been published by Jellison, Vinson and Helminen (**5**, **6**).

France: In May and June 1959, a brief survey of small mammals in France was made for the presence of *E. crescens*. The first animals to be examined, May 26, 1959, were at the Museum of Natural History, Paris, where specimens preserved in alcohol or formalin were autopsied. Some of these had been in storage for many years. These were made available to us through the courtesy of M. Petter, Curator of Mammals. The second jar of animals examined contained four moles, *Talpa europaea*, two of which were infected. A total of 28 small mammals were autopsied at the museum, but only these two proved to be infected.

During the month of June, Mr. Jacques Giban trapped small mammals in the vicinity of L'Herm and St. Michel, Vendee, and saved the lungs from all specimens collected. This collection consisted of 28 voles, *Microtus agrestis*, 5 shrews, *Sorex araneus*, and 17 musk shrews, *Crocidura* sp. Four of the 28 voles and 2 of the 17 musk shrews contained adiaspores of *Emmonsia* in their lungs. None were found in any of the shrews.

Also during the months of May and June a group of zoology students under the direction of M. Petter was trapping small mammals at Brunoy,

TABLE V

ANIMALS FROM FRANCE EXAMINED 1959–1960 FOR E. CRESCENS

Species	Museum	Fresh		Total	Number infected
		St. Michel	Brunoy		
Microtus arvalis, vole	5	28	0	33	4 (Fresh)
Crocidura sp., shrew	3	17	0	20	2 (Fresh)
Clethrionomys glareolus, red-backed mouse	10*	0	3	13	1 (Museum) 1 (Fresh)
Talpa europaea, mole	5	0	0	5	2 (Museum)
Apodemus sylvaticus, wood mouse	0	0	5	5	0
Sorex araneus, shrew	0	5	0	5	0
Arvicola sapidus, vole	4	0	0	4	0
Mus. sp., house mouse	1	0	0	1	0
Rattus norvegicus, rat	0	0	1	1	0
Mustela sp., weasel	1	0	0	1	0
Total	29	50	9	88	10

* 1 specimen from U. S. National Museum.

Seine et Oise, near Paris. After preparing study skins they saved the carcasses for autopsy. One of the 11 animals, a vole, *Clethrionomys glareolus,* was infected.

In December 1959 a number of small mammals in the United States National Museum, Washington, D. C., were examined. Most of the specimens were from South America but one animal, a vole, *Clethrionomys glareolus vasconiae,* from Ariege, Ax-les Thermes, France, March 1908, was found to be infected.

The collection data and findings on the 10 animals found to harbor this organism (TABLE V) are as follows:

No. 413-2-A & B. 2 moles, *Talpa europaea* (L.), Argenton-sur-Creuse, Indre, M. Rollinat, collector. Collected about 1900. (No date on specimen labels.) The lungs of one mole contained only two adiaspores measuring 266 μ and 348 μ in diameter, respectively. The cell wall on one of these spores was especially heavy and measured 74 μ in thickness. The second mole had very numerous spores in the lungs. Measurements of six spores averaged 346 μ diameter, cell walls were up to 72 μ in thickness.

No. 442. 4 voles, *Microtus arvalis,* St. Michel en L'Herm, Vendee, collected by Jacques Giban, June 1959. One vole had 17 or more spores, one had 2 spores 170 μ and 237 μ in diameter, one had one spore 177 μ in diameter and one had one spore 96 μ in diameter. From the size of the lung specimens, most of 28 voles in this collection appeared to be immature. The spores also had probably not reached maximum size.

No. 444. 2 musk shrews, *Crocidura* sp., St. Michel, Vendee, collected June 1959 by Jacques Giban. One had 10 or more spores in its lungs, one of which measured 170 μ in diameter. The other had two spores which measured 444 μ and 473 μ in diameter.

No. 451. Vole, *Clethrionomys glareolus,* Brunoy, France, 29 May 1959. Three spores in lung, one of which measured 340 μ in diameter with cell walls 59 μ thick.

RML No. 35379. Vole, *Clethrionomys glareolus vasconiae,* Ariege, Ax-les Thermes, March 1908, V. Bouilles, collector. Lungs contained one spore 370 μ in diameter with a cell wall 96 μ thick.

Since all of the above specimens were preserved in alcohol before examination, culture of the organisms was not possible.

The specimens found in mammals from France should be referred to the species *Emmonsia crescens,* at least until cultures have been estab-

lished and studied. However, the extremely thick cell walls, 50–96 μ, on some specimens from France, are quite distinctive.

An account of these studies in France has been published by Jellison et al. (**8**).

No difficulty should be experienced in establishing this organism in culture from rodents or other small mammals in France if someone will make the effort to do so.

Germany: No field work or examination of animals was done in Germany but visits were made to several scientific institutions. Since then Dr. Erika Pezenburg (D.V.M.) at der Institut fur Parasitologie, der Freien Universitat, Berlin, has reported (**11**) the presence of *Emmonsia* in a wild hare, *Lepus europeus*. The animal was collected in a forest of West Berlin. A spherule from this host which was sent to me measured 444 μ in diameter. Dr. Pezenburg has later stated in correspondence that she found *Emmonsia* in *Ondatra zibethica* in Germany and succeeded in culturing the organism from this host. The specific locality was not given.

Italy: A fungus culture isolated from soil in Italy was identified and reported as *Emmonsia* by Ciferri and Montemartini (**2**) but exact information on date and place of origin was not available. The isolate was infectious for laboratory animals.

TABLE VI

ANIMALS EXAMINED FOR ADIASPIROMYCOSIS IN YUGOSLAVIA, MAY 1959

Species	Examined	Infected
Rattus norvegicus, rats	19	0
Mus musculus, house mice	16	0
Talpa sp., moles	5	0
Lepus sp., rabbits	2	0
Microtus sp., vole	1	0
Ondatra zibethica, muckrat	1	1
Total	44	1

Yugoslavia: While in Yugoslavia one of the writers (W. L. J.) worked at the Central Health Agency Laboratory, Sarajevo. The Director of this Laboratory, Dr. Ante Jamnicki, arranged a visit to Bejeljina where small mammals were trapped and examined. A total of 44 animals were examined (TABLE VI) but at that time only one animal, a mature muskrat, *O. zibethica,* was found infected with *E. crescens.* Only 4 or 5 spherules were found in this specimen after processing in NaOH and cultures were not established.

In October and November 1959, Dr. Jacob Gaon, Faculty of Medicine, Sarajevo, arranged for the collection of additional small mammals in the vicinity of Bejeljina. These were autopsied and the lungs sent to us in alcohol for examination. As the lung specimens were somewhat broken up it was impossible to tell exactly how many animals were represented, but the following results are close approximations:

One of 64 *Microtus* sp. infected with *E. crescens;* 1 of 9 *Micromys minutus;* none of 9 *Mus musculus* and *Muscardinus avellanarius;* and 1 of 9 *Apodemus* sp. Preserved specimens of each kind of the small rodents accompanied the lung specimens and these rodents were identified by Dr. Henry Setzer at the U. S. National Museum.

SUMMARY

Emmonsia crescens Emmons and Jellison, 1960, a pulmonary fungus of mammals, had been reported for England, Sweden, and Italy.

A survey of small mammals in Europe in 1959 established that this organism was also present in Norway, Finland, France, Germany, and Yugoslavia. Additional infected animals were found and numerous cultures were established in Sweden.

Some of the interesting records of this pathogen were as follows:

Arvicola t. terrestris, a vole from Hamar Norway. Very heavily infected.

Microtus sp., a vole near Moi Rana, in northern Norway, 27 kilometers south of the Arctic Circle.

Microtus agrestis, a vole from Sweden collected in 1845 and preserved in the Swedish National Museum.

Lutra lutra, an otter from Kopparberg County, Sweden, very heavily infected.

Ondatra zibethica, the American muskrat introduced into Europe, and *Arvicola t. terrestris* from near Helsinki, Finland. Numerous specimens of both infected, some heavily.

Lemmus sp., a lemming from Kilpisjärvi, north Finland, 69° N.

This survey demonstrates that *E. crescens* has a wide host and geographical distribution in Europe.

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11. **Pezenburg, E.** Haplomykose beim Hasen. Zeit. fur Bakt. Parasit. Infekt. Hyg. **173**: 140. 1960.
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NOTES AND BRIEF ARTICLES

Notices

The American Type Culture Collection is developing an Information Center to compile the data published on the cultures in the Collection and to answer the numerous queries it receives. Furthermore the ATCC soon will be actively engaged in research with special emphasis on the characterization and taxonomy of microorganisms and on improved methods of preservation of microorganisms, including viruses, and cell lines. It is, therefore, imperative that the ATCC has a well equipped library at its disposal to support these functions.

Anyone interested in donating scientific journals, books, or reprints to the American Type Culture Collection library is asked to write to the Chief of Information, American Type Culture Collection, 2112 M Street, N.W., Washington 7, D. C., for further details.

Papers presented as part of a special symposium on Fundamental Development in Plant Growth in conjunction with the A.A.A.S. meetings held in New York City on December 27, 1960, sponsored by The Torrey Botanical Club, are now available in Volume 88, Nos. 4 and 5 of the Bulletin of the Torrey Botanical Club. The following papers are included: Vol. 88, No. 4, Changing Concepts of Photosynthesis by Daniel I. Arnon; Vol. 88, No. 5, Fundamental Developments in the Field of Plant Growth Regulators by John W. Mitchell, Alteration of Plant Growth by Chemicals by N. E. Tolbert, Antimetabolites and Plant Growth by Thomas H. Jukes, Test-tube Studies on Flowering: Experiments with the Lemnaceae by William S. Hillman, Photoperiodic Control of Flowering by H. A. Borthwick, Plant-animals as Experimental Tools for Growth Studies by S. H. Hutner, Recent Progress and the Goals of Plant Tissue Culture by Walter Tulecke. Copies of the two issues are available singly for $1.50, or both for $2.75. Orders should be placed with Howard W. Swift, Manager of Publications, The Torrey Botanical Club, The New York Botanical Garden, New York 58, N. Y.

MUSHROOM POISONING SINCE 1924 IN THE UNITED STATES

The following is a list of deaths from mushroom poisoning that have been reported in the United States since 1924. Probably at least as many more have not been recorded. Reports of overlooked or additional cases, with date and name of the mushroom concerned, will be welcome in order to make the record as complete as possible.

1924. J. Dearness, Mycologia **16**: 199, July, 1924. One death in Norfolk, Ontario, Canada. *Gyromitra esculenta* (Pers.) Fr.

1932. J. B. VanderVeer and D. L. Farley, Arch. Int. Med. **55**: 773–791, May, 1935. Two deaths near Trenton, N. J. *Amanita phalloides* (Fr.) Secr.

1934. J. A. Williams and E. V. Perrin. Personal communication, June 23, 1961. One death in Cincinnati, Ohio. White *Amanita phalloides.*

1934. J. W. Hotson. Mycologia **26**: 194, March–April, 1934. One death in Anacortes, Wash. *Amanita pantherina* (Fr.) Quél.

1936. J. H. Ahronheim. Jour. Mich. State Med. Soc. **37**: 921, October, 1938. One death. *Amanita phalloides.*

1938. J. O. Cottingham. Proc. Ind. Acad. Sci. **65**: 210, 1955. Five deaths reported by C. M. Christensen of the Univ. of Minn., in Pine River, Minnesota. *Gyromitra esculenta.*

1939. Suffolk County (Mass.) Medical Examiner's Office. One death. ? *Amanita phalloides.*

1940? H. V. Hendricks. Jour. Am. Med. Assoc. **114**: 1625, April 27, 1940. One death in Kalkaska, Mich. *Gyromitra esculenta.*

1942. N. Y. Times, Sept. 16, and N. Y. State Dept. of Health. Kenmore, N. Y. Two deaths.

1944. E. R. Perez. Personal communication. One death in Santa Cruz, California.

1949. E. F. Luh. Personal communication. June 30, 1961. One death in Canton, Ohio. ? *Amanita phalloides.*

1949. C. D. Cook and R. J. Haggerty. New England Jour. Med. **262**: 832–833, April 21, 1960. One death in Putnam, Conn. *Amanita phalloides.*

1949. N. Y. Times, Oct. 22, and Dept. of Health, City of N. Y. Two deaths.

1950. N. Y. Times, Sept. 24, and Bender Hygienic Laboratory, Albany, N. Y. One death. ? *Amanita phalloides.*

1951. Faulkner Hospital, Jamaica Plain, Mass. One death from "mycetismus, choleriform type."

1952. C. D. Armstrong. Stanford Med. Bull. **13**: 111–116, May, 1955. Two deaths in California. *Amanita phalloides.*

1954. N. E. Davies. Personal communication, July 12, 1961. One death in Charlottesville, Virginia.

1954. Dept. of Health, City of New York. One death, "wild mushrooms."

1955. N. Y. Times, Aug. 31, and St. Joseph's Hospital, Yonkers, N. Y. One death.

1957. U. S. Naval Hospital, Camp Le Jeune, N. C. June 6. One death, "Toadstool."

1959? V. Potter. Personal communication, July 3, 1961 and newspaper clipping from Gratiot County Herald (Ithaca, Mich.), undated. One death in Alma, Mich.

1960. L. R. Kneebone. Personal communication, June 28, 1961. Two deaths in Berks County, Penna.

1960? D. L. Flogstad. Wisconsin Med. Jour. **60**: 333–335, June, 1961. One death in Shell Lake, Wis. Probably *Amanita phalloides*.

1960. E. L. McCawley, Portland, Ore. Personal communication. One death in Milwaukie, Ore. *Psilocybe baeocystis*.

1961. Dr. M. M. McLeod, Sanford, N. C. Personal communication. One death.

1961. W. Virginia Dept. of Health, Charleston, W. Va. One death.

—ROBERT W. BUCK, M.D., 22 The Fenway, Boston 15, Mass.

MYCORRHIZAL FUNGI ON PINUS VIRGINIANA

Previously, the only reported mycorrhizal fungi on *Pinus virginiana* Mill. were described by Hacskaylo (**1953**) and Hacskaylo and Palmer (**1955**). They proved that under aseptic conditions five American Basidiomycetes, *Amanita caesaria* (Fr.) Schw., *A. frostiana* (Pk.) Sacc., *A. rubescens* (Fr.) S. F. Gray, *Boletus bicolor* Pk., and *Lepiota rhacodes* (Vitt.) Quél., and two Swedish Basidiomycetes, *Boletus variegatus* Fr. and *Rhizopogon roseolus* (Corda) Th. Fr., could become mycorrhizal partners with *P. virginiana*. We have investigated possible mycorrhizal relationships with this pine using several other species of fungi.

Positive mycorrhizal associations were determined by using Melin's (**1922**) aseptic culture method as revised by Hacskaylo (**1953**). The pine seedlings were grown in flasks on a vermiculite and nutrient solution substrate for one month. Inoculations were then made by using blocks of mycelium grown on nutrient agar. Six weeks to two months later, the roots of the seedlings were examined for mycorrhizae. The results of the investigation were as follows:

A. Mycorrhiza-formers. *Amanita flavorubescens* Atk., *A. mappa* (Fr.) Quél., *A. muscaria* (Fr.) S. F. Gray, *A. solitaria* (Fr.) Karst.,

A. verna (Fr.) Vitt., *Boletus betula* Schw.,[1] *B. cyanescens* Fr., *B. edulis* Fr., *B. felleus* Fr., *B. frostii* Russ., *B. indecisus* Pk., *B. luteus* Fr., *B. pallidus* Frost, *B. punctipes* Pk., *B. rimosellus* Pk., *B. subtomentosus* Fr., *Cenococcum graniforme* (Sow.) Ferd. & Winge, *Paxillus rhodoxanthus* (Schw.) Bres., *Russula emetica* (Fr.) S. F. Gray, and *Scleroderma aurantium* Pers.

B. Nonmycorrhiza-formers. *Amanita abrupta* Pk., *A. phalloides* (Fr.) Secr., *Amanitopsis parcivolvata* Pk., *A. strangulata* (Fr.) Quél., *Boletinus squarrosoides* Snell & Dick, *Boletus affinis* Pk., *B. badius* Fr., *B. retipes* Berk. & Curt., *B. separans* Pk., *Lycoperdon gemmatum* Batsch, and *Strobilomyces strobilaceous* (Fr.) Berk.

Although the fungi in group B did not enter into a mycorrhizal association with *Pinus virginiana*, they are not to be totally discounted as mycorrhizal fungi. Other than *Amanitopsis strangulata*, which grows comparatively fast, these fungi did not grow well in the substrate. Thus they might not have become intimately enough associated with the seedling roots to form mycorrhizae and further study may show that they definitely are or are not capable of forming mycorrhizae with *P. virginiana*.—J. A. VOZZO AND E. HACSKAYLO, Forest Physiology Laboratory, Forest Service, U.S.D.A., Beltsville, Maryland.

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THE EFFECT OF TANNIN ON THE GROWTH OF SELECTED SOIL MICROFUNGI IN CULTURE

While investigating the effect of various organic compounds on the growth of selected species of microfungi isolated from Wisconsin soils, it was observed that tannin (Nutritional Biochemicals Corp.) exerted a pronounced inhibitory effect on those species primarily associated with prairie soils, whereas it had no adverse effect on a majority of the species which were either prominent in forest soils or contributed significantly to

[1] Culture obtained from W. C. Bryan and B. Zak, Forest Service, Southeastern Forest Experiment Station.

microfungal populations in both forest and prairie soils. Although a number of investigators have demonstrated the capacity of certain fungi, primarily Penicillia and Aspergilli, to hydrolyze or utilize tannin (**4**), no one has alluded to its possible role in influencing the colonization of certain soils by microfungi.

The fungal strains used in this investigation (TABLE I) were subcultures of organisms isolated by Tresner et al. (**5**) from hardwood forest soils and by Orpurt and Curtis (**3**) from prairie soils. These investigators concluded that discrete microfungal communities, in which particular species are consistently associated, are not apparent in prairies and southern hardwood forests of Wisconsin; rather, the species combinations change progressively along the gradient of both the forest and prairie continua. Most of the species selected for this study exhibited well-defined maxima in different segments of their respective continua when frequency of occurrence within a stand was plotted against the continuum index numbers of the stands. The forest continuum extends from the pioneer, relatively dry, bur oak (*Quercus macrocarpa*) forest to the climax, mesic, maple (*Acer saccharum*) forest. The prairie continuum includes dry, mesic, and wet prairies, as described by Curtis (**1**).

Each organism was cultured on 4 different media; these were modified Czapek's solutions in which respectively 1.5% glucose (6 g carbon/liter), 0.5% glucose, 1.15% tannin (6 g carbon/liter), and 0.77% tannin +0.5% glucose (total of 6 g carbon/liter) were substituted for the sucrose carbon source. Stock solutions of the carbon sources were autoclaved separately from the mineral salts solution. The media containing 1.5% and 0.5% glucose served as the controls. One other modification involved substitution of ammonium sulfate for sodium nitrate in the culture medium for *Mucor hiemalis*. The fungi were grown on 20 ml of nutrient medium in standing liquid cultures. The media were adjusted to pH 6.5, inoculated with a spore suspension and incubated at room temperature (21–24° C) for 7 days, at which time the mycelia were harvested, dried at 85° C for 12 hr and weighed. Each weight recorded in TABLE I is an average of 4 replicates.

The species listed in TABLE I have been arranged in groups representing the type of higher plant community in which they were a prominent component of the microfungal population. When the species are arranged in this manner, there appears to be a correlation between absence of fungal growth in the presence of tannin and the habitat from which the strain was isolated. Tannin inhibited the growth of all prairie species tested, although a readily available carbon source was present in the medium. The exact nature of this inhibition is unknown; however, it

TABLE I

GROWTH (MG DRY WEIGHT) OF SELECTED SPECIES OF SOIL MICROFUNGI IN THE PRESENCE AND ABSENCE OF TANNIN

	1.5% Glucose	0.5% Glucose	1.15% Tannin	0.77% Tannin 0.5% Glucose
A. Prairie species				
Alternaria tenuissima (Fr.) Wiltsh.	18.4	6.6	0	0
Aspergillus fumigatus Fres.	32.7	16.0	0	trace
Aspergillus terreus Thom	85.6	44.1	0	15.0
Emericellopsis microspora Backus & Orpurt	29.1	14.6	0	0
Fusarium oxysporum Schlecht.	26.2	13.5	0	0
Penicillium lilacinum Thom	44.1	24.7	0	0
Phialophora sp.	16.5	11.6	0	0
Thielaviopsis sulphurellum	35.4	21.5	0	0
B. Species in both prairie and forest soils				
Absidia glauca Hagem	36.3	22.8	0	0
Mucor hiemalis Wehmer	37.9	30.7	0	0
Paecilomyces marquandii (Mass.) Hughes	32.7	16.0	0	0
Penicillium implicatum Biourge	106.0	42.6	53.4	73.7
Penicillium janthinellum Biourge	16.8	7.7	12.0	7.1
Penicillium nigricans (Bain.) Thom	66.0	37.0	30.1	93.9
Penicillium purpurogenum Stoll	75.6	45.5	0	0
Penicillium restrictum Gilman & Abbott	33.3	12.5	0	0
Penicillium roseo-purpureum Dierchx	74.6	31.3	0	0
Penicillium simplicissimum (Oud.) Thom	46.7	35.8	78.8	110.0
Penicillium variabile Sopp	105.1	34.0	49.4	71.2
C. Forest species				
Oospora sulphurea (Preuss) Sacc. & Vogl.	21.4	12.3	0	0
Penicillium granulatum Bain.	42.6	25.2	48.4	73.7
Penicillium herquei Bain. & Sart.	21.9	9.6	42.9	59.8
Penicillium spinulosum Thom	21.8	12.5	13.0	12.4

cannot be attributed to an adverse pH of the culture medium. In contrast, the species prevalent either in forest soils alone or in both forest and prairie soils exhibited mixed reactions toward tannin under the conditions employed. A majority of these species not only grew when tannin was present in the culture medium, but were able to utilize it as a carbon source.

It would appear, then, that tannin may be one of the factors influencing the distribution of certain species of soil microfungi and may account in part for the observed differences in the character of fungal populations in soils of forests and prairies in close proximity. If this hypothesis is correct, then prairie litter would be expected to have a relatively low tannin content, whereas forest litter should have greater concentrations. Water extracts of litter from each of the two community types were tested for the presence of tannin using a ferric chloride test (**2**). Only traces

of tannin could be detected in prairie plant litter while both oak and maple leaf litter contained an abundance of the compound, although it was more readily leached from the latter. Substantiating evidence supporting the identity of the extracted tannin was possible by determining the decomposition temperatures of crystals formed by the extracts upon evaporation of the solvent. Crystals from the oak litter extract decomposed at 267° C and those from the maple litter extract at 266° C, while an accepted range for digallic acid, the major constituent of tannin, is 268–270° C.—G. T. COWLEY AND W. F. WHITTINGHAM, Department of Botany, University of Wisconsin, Madison.

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